SCIENCE ABSTRACTS.

Section A.—PHYSICS.

APRIL 1919.

GENERAL PHYSICS.

360. *The Contact Lever Apparatus for measuring Elasticity.* **C. Barus.** (Nat. Acad. Sci., Proc. 5. pp. 44–49, Feb., 1919.)—Small lengths of a few cm. of brass, glass, or ebonite are here tested for elasticity on the interferometer. Curves of hysteresis are shown and the working of the apparatus is discussed.
P. E. S.

361. *A Machine for measuring Screws.* **P. E. Shaw.** (Engineering, 107. pp. 104–106, Jan. 24, 1919.)—This machine deals with the measurements of diameter and pitch both of ordinary plug screws and of ring screws, and also of tapered plug screws and ring screws. But the outstanding feature of the device is its application to the measurement of the diameters of ring screws to an accuracy never previously approached. The customary method used is to employ "checks"; an artificial and costly system and one which cannot conceivably give the accuracy desired, *i.e.* to 0·1 mil. The principle employed here is to measure the full depth (d) of thread and the effective depth (e) of thread. (In the ideal thread $e = d/2$.) The outstanding diam., which is the full diam. for a plug and the core diam. for a ring, is independently measured. Then by combining this diam. with the values d and e, we ascertain all the three diams. The mechanism consists of a beam rotating about its centre, one end bearing by a special pin on the screw surface, the other end bearing by another pin on an optical lever. To enable the special pin to come in contact with various parts of the thread profile, the beam has two motions provided: (1) the rotation above mentioned, and (2) a sliding action parallel with the axis of the screw being measured. The rotation of the beam produces a rotation of the optical lever and, a telescope and scale being provided, the observer reads on a scale the dimensions of the thread profile.

The above method can be modified so as to dispense with the necessity of having an accurate scale; a micrometer is used to bear on the beam and so give direct readings. Differently shaped special pins are provided according as full depth or effective depth is being measured; and the dimensions of the pin depend on the pitch and type of screw being measured. But there is no difference, either in the pins or in the method of use, between the case of a plug or of a ring of the same pitch and type.

There is no accurate micrometer on the market for measuring the core diameter of a ring; but a method is provided on this machine for this purpose. Supposing this core diam. is measurable as accurately as the full diam. of a plug, *i.e.* to 0·1 mil, then the ring diams. can be found as accurately as the plug diams., *i.e.* to, say, 0·2 mil.

Pitch is measured in a direct way on the same machine, modified by the use of a special beam and a micrometer directed horizontally, *i.e.* parallel to the axis of the screw being measured. There are several advantages in this machine, thus: (1) all screwed plugs and rings from diameter 1/4 in. to, say, 8 in. can be measured; (2) the pressure between the measuring pins and the screw surface is small, so that wear of the surface is negligible. AUTHOR.

362. *Transformation from an Uneven to an Even Scale.* **H. Krüss.** (Zeits. Instrumentenk. 38. pp. 195–200, Dec., 1918.)—In Fig. 1 if APC be a cam groove, EP and PD being equal arms linked at P, it is possible, by varying the form of the groove, to convert an uneven motion of E into an even motion of D. This may be used, for instance, in the case of a spectroscope (see Fig. 2) to give an even scale of wave-lengths for the motion of the screw moving the telescope. J. W. T. W.

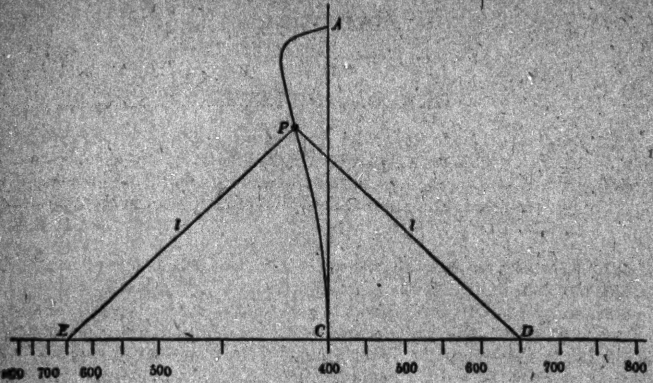

FIG. 1.

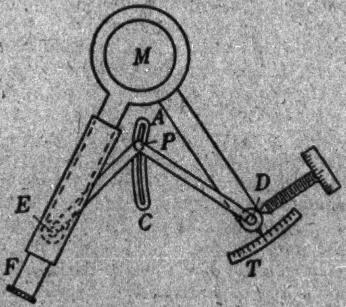

FIG. 2.

363. *A New Contact Lever, using Achromatic Fringes.* **C. Barus.** (Nat. Acad. Sci., Proc. 5. pp. 39–43, Feb., 1919.)—The method of measuring small angles by the rectangular interferometer is here applied to delicate devices such as the contact lever or the spherometer. P. E. S.

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364. *Measurement of Vertical Air Speed of an Aeroplane.* **C. Schoute, F. A. van Heyst,** and **N. E. G. Meyer.** (K. Akad. Amsterdam, Proc. 21. 4. pp. 468–475, 1919.)—Describes an instrument, termed a "scansimeter," which gives the pilot a continuous indication of his vertical velocity relative to the air. The instrument consists essentially of a dynamo driven by a small air-screw, the lines of the magnetic field being maintained horizontal by pivoting the magnet about a horizontal axis. J. W. T. W.

365. *Design and Test of Standards of Mass.* (Bureau of Standards, Circ. No. 3. [89 pp.], Washington, 1918.)—Details as to the design of standard masses and the materials to be employed in them are specified. Next, the processes employed in their comparison with the national standards are given. This section of the circular includes the methods used for testing a single weight, for testing several equal weights, and for intercomparison of the weights of a set; and charts are shown such as are used in the recording of these tests. The next section deals with the corrections to be made for the buoyancy depending on the temperature, the barometric pressure, and the hygrometric condition of the air. The range of density of weights used ranges from 21·5 to 2·7 for Pt and Al respectively, with the commonly used intermediate value of 8·4 for brass. The simple correction formulæ are given. There is an appendix containing 15 tables of various data relating to density values, conversion tables, etc. P. E. S.

366. *Graphical Records by a Gas Jet.* **L. Lumière.** (Comptes Rendus, 167. pp. 1068–1070, Dec. 30, 1918. Rev. Gén. d'Él. 5. p. 334, March 1, 1919.)—It is known that the use of a smoked paper to receive the displacements of a style, for registering the variations in some phenomenon physical or physiological, suffers from the objection that the friction may vitiate the curves thus traced. The author removes this objection by using a fine jet instead of the style and a paper chemically prepared instead of smoked. Then the jet delivers a gas which reacts on the paper and so leaves the desired trace. To obtain a sharp effect the author at first used a jet of air charged with sulphuretted hydrogen and a paper impregnated with a metallic salt such as acetate of lead. These reagents were afterwards abandoned in favour of ammoniacal gas and acetate of mercury. E. H. B.

367. *On the Minimum Number of Associated Spirals.* **J. Andrade.** (Comptes Rendus, 168. pp. 139–141, Jan. 20, 1919.)—The object of this paper is to complete, from the standpoint of practical application (*e.g.* to chronometric apparatus and exact balances), the work of the author on associated spirals begun in 1911. He now shows how with a minimum number of such spirals suitable adjustments may be made whereby the following mechanical effects can be produced either separately or in combination, namely: (1) Production upon an oscillating solid of a pure couple whose plane is rigidly perpendicular to the axis of oscillation, *i.e.* suppression not only of all pressure transverse to this axis, but even of all pressure longitudinal to it. (2) Production upon an oscillating solid of a pure couple whose intensity is proportional to the angle of oscillation, whatever might be the magnitude of the latter, and with a constant precision attaining to $\frac{1}{100000}$ or even to a millionth. H. H. Ho.

368. *Resistance of Metals to Penetration under Impact.* **C. A. Edwards.** (Inst. of Metals, J. 20. pp. 61–88; Disc. and Corres., 89–108, 1918. Engineering, 106. pp. 285–289, Sept. 13, 1918.)—Gives the results of experiments carried out with the apparatus described in Abs. No. 886 (1918) and designed for making dynamic hardness determinations of metals. For this work 4 balls of varying diameter and 4 cones of different angles were used as strikers, and the results together with Brinell and scleroscope hardness numbers are given for Pb, Al, Sn, and brass. The work of Martel is referred to and the Martel hardness number is calculated for each observation.

A note on the hardness of solid elements as a periodic function of their atomic weights is added to the paper, together with a diagram to illustrate this point. Although a distinct relationship is shown, there is an even closer parallelism between the curves for hardness and absolute melting-points. Practically all the changes in the melting-point curve are reflected by corresponding changes in hardness. C. O. B.

369. *The Premature Rupture of Steel under Repeated Stresses.* **C. Frémont.** (Comptes Rendus, 168. pp. 54–56, Jan. 6, 1919.)—The work of Wöhler and other German investigators of the effects of repeated stresses has been made on the tacit assumption that the max. "fatigue" stress can be equated to a *static* stress which is the max. fibre stress that is set up at any point. This is denied by Frémont, who believes that so long as stresses not exceeding the elastic limit only are involved, rupture would never occur, however often the stresses are repeated. Rupture under alternating stress is therefore believed to be due to the max. stresses involved exceeding the elastic limit. Believing this, the number of failures of railway axles has been considerably reduced by choosing steels of high elasticity. Segregations and inclusions result in early deterioration. In investigating the local effects of stresses Piobert's lines are utilised. (These are identical with the commonly called Lüder's lines. Piobert discovered them in 1836; Lüder rediscovered them in 1854.) F. C. T.

370. *Static, Dynamic, and Notch Toughness.* **S. L. Hoyt.** (Am. Inst. Mining Eng., Bull. No. 146. pp. 339–351, Feb., 1919.)—The presence of a notch, the result either of bad design or faulty workmanship, results in local stresses of a high order which may cause fracture. A structure consisting of large areas of ferrite and pearlite and marked lamination in the latter, offers little resistance to failure at a notch. The same steel, when heat-treated to give a sorbitic structure, either by oil quenching or, better, water quenching and tempering, will oppose a far greater resistance. Keyways are a common example of notch effects due to design. The toughness of normal carbon steels increases up to 0·3 % C if measured by the area of the stress-strain diagram. The notched-bar impact test is suggested as being the only satisfactory method of measuring toughness. Forging at an excessively high temperature results in a lack of toughness, well shown by the Charpy test, which is hardly shown by the tensile test. The tensile test, further, does not indicate the superior toughness of well-treated alloy steels nearly so well as does the notched-bar test, and it is at times possible to obtain from two samples of a steel identical tensile results, with, however, widely different degrees of toughness and of notched-bar impact resistance. The impact shear test of McAdam is far less useful. F. C. T.

371. *The Experimental Study of the Mechanical Properties of Materials.* **W. C. Unwin.** (Inst. Mech. Eng., J. No. 6. pp. 405–439, Nov., 1918. Thomas Hawkesley Lecture.)

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372. *Critical Speeds of a Whirling Shaft.* **A. Lechner.** (Akad. Wiss. Wien, Ber. 126. 2a. 10. pp. 1855–1862, 1917.)—Investigates the effect of the elasticity of the shaft material on the principal critical speed of a rotating shaft with eccentric loading, and shows that this is always lower than the value obtained by neglecting this elasticity. J. W. T. W.

373. *Critical Distributed Loads for Long Struts.* **A. Morley** and **F. F. P. Bisacre.** (Engineering, 107. pp. 99–100, Jan. 24, and pp. 129–131, Jan. 31, 1919.)—Extends the method of successive approximation previously applied to other cases [Abs. 1220 (1917)] to the calculation of the critical load of compression members of cantilevers or masts. The paper gives general formulæ applicable to different varieties of distributed loads, and a comparison of the results thus obtained with those given by rigorous solutions in certain cases. Information relative to the ideal collapsing loads for struts with various types of loading is given in a form immediately useful to the designer, while the effects of varying moments of inertia of cross-section are considered in several cases. J. W. T. W.

374. *Approximate Graphical Treatment of Strut Problems.* **J. Case.** (Engineering, 106. pp. 699–700, Dec. 20, 1918.)—Applies to various strut problems the method of graphical analysis introduced by H. A, Webb [see Abs. 326B (1918)]. Using this method to obtain the crippling load of a pin-jointed strut of varying section, the deflection curve is taken as a simple cosine curve, and the equation obtained is $\mathrm{E/P}\int_0^{l/2}\int^x (\cos \pi x/l)/\mathrm{I}\,.\,dx\,.\,dx$, the double integration being performed graphically, and set out in full in the paper. The appropriate equations for (i) a strut with lateral load, (ii) the same with terminal couples in addition, (iii) a continuous beam with end load, are similarly obtained. J. W. T. W.

375. *On the Energy Components of the Gravitation Field.* **W. Pauli, Jr.** (Phys. Zeits. 20. pp. 25–27, Jan. 15, 1919.)—The energy components of the gravitation field have hitherto only been explicitly calculated for the special case $g = -1$, and not for any given system of coordinates. The present paper is intended to supply this omission, so that the energy components t_i^k of the gravitational field are now developed for the general case. The expression obtained is valid for a coordinate system in which $g = -1$, as well as for the Einstein approximation solution. The result, on comparison with known expressions, indicates that the energy components are not uniquely determined. The paper is mathematical throughout. H. H. Ho.

376. *Propagation Velocity of Diffusion.* **P. Frank.** (Phys. Zeits. 19. pp. 516–520, Dec. 1, 1918.)—Usually the propagation velocity of diffusion is regarded as infinitely great compared with the finite velocity of elastic and electrical disturbances. This idea originates from the fact that, starting with an empty space, the presence of a substance diffusing into it can be detected almost immediately in the most remote part. Mathematically, however, diffusion is a much slower process, and this receives explanation when the diffusing substance is regarded as a finite number of molecules. A definite time must in consequence elapse before the first molecule enters any particular portion of the space, and therefore a finite propagation velocity must exist. In the present paper the diffusion velocity is treated as the velocity with which the head of a swarm of particles moves forward, and the consequence is developed that the velocity increases without limit with the number of the particles. In an appendix, the diffusion velocity is treated from the alternative standpoint of the velocity of the max. concentration, and is analogous to Fourier's method for thermal conductivity. This mode of consideration is then applied to the Brownian movement. H. H. Ho.

377. *On a Simplified Case of the Formulæ of Boussinesq.* **Mesnager.** (Comptes Rendus, 168. pp. 156–158, Jan. 20, 1919.)—The author, after quoting numerous references of publications on the Boussinesq problem, points out that no one seems to have drawn attention to the remarkable simplifications which are produced in the formulæ for bodies in which Poisson's coefficient attains the value 0·5, or, otherwise stated, where $\lambda = \infty$, $\mu/\lambda = 0$; *e.g.* substances of invariable volume (alloy composed of 0·67 Ag with 0·33 Pt, india-rubber, etc.). For application to experimental investigations, these simplifications are important, and the elasticity formulæ relative to these bodies give very close relations between the solutions for two and three dimensions. The results which Boussinesq found for pressures on planes parallel to the surface are shown by the author to apply to elements in any direction whatever. He states his result as follows:—"Every external force acting at a point on the plane surface of a solid otherwise unlimited but of invariable volume, is transmitted upon any interior element M in the form of a pressure directed along MP and of magnitude equal to the product of the coefficient $3\pi/2$ by the projection, in this direction, of the external force multiplied by the cosine of the angle which MP makes with the normal to the element M, and by the inverse of the square of the distance MP." Whether the body be limited or unlimited, and is only acted upon at the surface or at the interior by forces applied to a finite volume, all the tensions may be obtained by superposition of the simple solutions given in the paper. H. H. Ho.

378. *Invariant Integral of Hydrodynamics and its Application to General Relativity.* **E. Vessiot.** (Comptes Rendus, 167. pp. 1065–1068, Dec. 30, 1918.)—Has reference to a triple integral in Minkowski's four-dimensional space. [See Abs. 900 (1918).] E. H. B.

379. *Relativity and Gravitation.* **W. Wilson.** (Phys. Soc., Proc. 31. pp. 69–78; Disc., 78, Feb. 15, 1919.)—The author gives a brief and simple outline of Minkowski's achievement in fashioning the relativity hypothesis of recent physics into a structure of definite form which entitled it to bear the name of relativity theory. This he effected through perceiving that the Lorentz transformation was simply the extension to a four-dimensional world of a change of axes in three dimensions. He then derives the four pairs of equations of motion of a particle acted on by no forces in the Hamiltonian form: $dp_s/d\tau = -\partial H/\partial x_s$, $dx_s/d\tau = \partial H/\partial p_s$, $s = 1, 2, 3, 4$, where p_s is the s-component of the 4-vector momentum, x_s the corresponding coordinate, and τ the Minkowskian *Eigenzeit*. It is then shown that these are also the equations of motion in the gravitational field of Einstein's theory, and a formal proof is given of their identity with the corresponding equations given by Einstein in far more complex form; and previously by Dedekind in a note to a paper of Riemann's [*Ges. Werke*, 1876, p. 254]. Einstein's theory is simply a following up of speculations of Riemann, and what is new in his work is the application made of Riemann's ideas, and the mode of determining the coefficients. G. W. de T.

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380. *Gravitational Tensors of Einstein's Theory.* **T. de Donder.** (K. Akad. Amsterdam, Proc. 21. 3. pp. 437–445, 1919.)—The author points out that in a previous note [*Ibid.* Verslag, 25. May, 1916] he obtained a gravitational tensor subsequently obtained independently by Lorentz [*Ibid.* June, 1916]. In the present paper, which appears to be supplementary to a recent paper of the author's [Archives Musée Teyler (Ser. 2.) 3. 1917], the value of the tensor $t_{\lambda\mu}$ is given explicitly, and hence that of the tensor $t_{\lambda\mu} + T_{\lambda\mu}$ deduced. In the latter the second derivatives of the gravitation potentials have disappeared. It is shown that in any gravitational and electromagnetic field the generalised forces F_λ ($\lambda = 1, 2, 3, 4$) vanish, the result being obtained by means of Hilbert's identity; they also vanish when matter is present in the field, a result independent of the gravitational tensor selected out of the infinite range of possible ones. Various gravitational tensors are here considered, and one obtained by Einstein [Preuss. Akad. Wiss. Berlin, Ber. Oct. 26, 1916] is obtained in a corrected form. It is further shown that $\sum_\lambda t_{\lambda\lambda}$ is independent of the second derivatives of the gravitation potentials, and finally, as a consequence of the covariance of $t_{\lambda\mu}$, that the latter is cogradient with the electromagnetic tensor $T_{\lambda\mu}$ for every linear transformation of the variables.

G. W. de T.

381. *Essence of Physical Relativity.* **J. Larmor.** (Nat. Acad. Sci., Proc. 4. pp. 334–337, Nov., 1918.)—L. Page has obtained [Abs. 471 (1918)] an expression for the translatory force required to sustain a given varying velocity in an electrostatic system of the type usually taken, for analytical discussions, as the model of an electron, and applies it to challenging the result that an isolated radiating system is subject to a retarding force from the reaction of its own radiation of amount equal to the product of its velocity and rate of radiation divided by c^2, which is in conflict with the relativity contention which asserts that the velocity of an isolated body is meaningless. But the expression contains terms involving the acceleration of the system and its time gradients, and although the thrust of the radiation is then compensated, the velocity appears to be involved in the same manner as in the impugned result. Moreover, if the velocity can have no meaning, neither can the acceleration.

After insisting on the importance of this question, essentially that of the ether with uniform motion, which is destined perhaps to throw light on the nature of the forward momentum convected by radiation, and thence on the intimate dynamical nature of radiation itself and the physical function of the ether, the author suggests that the representation, now so unusual, of the electron as an aggregate of differential elements of electricity is, except for provisional illustration, far too narrow a foundation for its internal properties. If electricity is to be explained as consisting of electrons, it is not a forward step to explain electrons as consisting of electricity. The kinetic reaction of the inertia of an electron would then appear, as in Page's paper, in the very artificial form of a self-retarding force exerted by the electron on itself. Moreover, there is no assignable reason for the aggregation of electricity into electrons, unless other forces and constraints extraneous to the electric theory are to be introduced to hold them together. An ether theory, on the other hand, requires the existence of electrons, as the singularities in its constitution by which its activity is determined, and they formed an essential part of electrodynamic theory before they were detected in the free state, and the magnitude of their inertia was determined, together with their interaction at distances great compared with the magnitudes of their nuclei. This may be æolotropic; it may, even, when waves can travel, be a function of the velocity; but it must be the same whether the system which is its seat move with acceleration or not. And neither the momentum, of type mv, nor the energy of translation, of type $1/2\ m'v^2$, where m' may differ from m, can involve the acceleration. Otherwise all existing general dynamical theory would be dissolved. The acceleration gradients in Page's formula have no place in this scheme, and some origin extraneous to the electron must be assigned to them. On an ether theory that cause is the radiation from the electron in varying motion, which convects somehow mechanical momentum away from it into the free state. However we may clothe our thought in the language of relativity, it would appear that this issuing radiation does effectively possess an absolute velocity c, and therefore an absolute velocity of its source also is theoretically determinable from observations made in relation to it: and this seems to explain how Page's formula for the force on an isolated system can involve the acceleration of this system and its velocity also.

The true essence of the relativity of external knowledge is that we can investigate a system only in relation to some other system, and this has hitherto been the Newtonian system of space and time, the canonical system with respect to which dynamical principles take on an ideally simple form, and one which is being determined with continually increasing precision by astronomical progress. The two questions now in evidence are :—Is it now expedient to exchange this reference frame, corresponding to c infinite, for another far more complex but very slightly different continuum with a finite space-time modulus c? And the more fundamental question is—Are we to assign to either frame dynamical properties, typified by propagation of physical effects in space in terms of undulations sustained by stress and inertia, or are we to assign to it properties solely geometrical, and regard all physical effect as merely projected in duration across space? The interlaced fabric of electric and optical science has been actually constructed on the Newtonian framework as foundation, while the rival order of ideas seems to offer as yet only somewhat disjointed and ingenuous, though significant, expressions for striking features of recent discovery which the former has not yet succeeded in assimilating, and yet appears to invite us to obliterate the course of evolution of the science or perhaps to retain it as a mere historical survival. All these restatements of departments of physics in more expressly relative terms may be comprehended as partial analytic developments of the purely relational character of our external knowledge, so that in these matters it is no question of refuting any theory, for all are relative: it is fruitless to traverse any proposition without reference to the definitions and context on which it subsists. The question is, as to which formulation gives as a whole the closest and most expressive representation of the complex of natural knowledge, and affords the most promising clue to its further elaboration and extension. But such choice by no means precludes development along other promising but provisional lines for which an interpretation has yet to be found.

G. W. de T.

382. *Theory of Relativity.* **E. Guillaume.** (Archives des Sciences, 46. pp. 281–325, Dec., 1918.)—A general discussion of the subject with a special reference to universal time, the introduction of which is said to lead to the substitution of clear physical notions in place of very abstract ones.

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383. *General Relativity Theory.* **H. Bateman.** (Phil. Mag. 37. pp. 219-228, Feb., 1919.)—The author points out that as far back as 1909 he proposed a system of electromagnetic equations which are covariant for all transformations of coordinates which are bi-uniform in the domain we are interested in. They were similar to Maxwell's save that the relations $B = \mu H$, $D = kE$ were replaced by more general ones which implied that two fundamental integral forms were reciprocals with regard to a quadratic differential form $\Sigma\Sigma g_{mn} dx_m dx_n$, assumed invariant for all transformations of coordinates, and the coefficients of which were taken as characteristics of the medium supporting the field and of its motions, while its vanishing was regarded as the condition that two neighbouring particles should be in positions such that a disturbance starting from one at its associated time should arrive at the other at the time associated with it. It was further suggested that these coefficients might be viewed as characteristic of the mind interpreting the phenomena, and a transformation of coordinates as a crude model of a more general correspondence which might be regarded as an entity capable of growth and variation and as forming a crude mathematical symbol for a mind. The unconscious normal functioning of bodily processes might then find an analogue in the physical relativity principle. If the nature of an electromagnetic field be assumed to depend on the type of quadratic form determining the constitutive relations, this dependence might also be a symbol for the relation between gravitation and light as assumed by Einstein; but it might just as well be a symbol for the relation between physical and mental phenomena; on the other hand, each of these sets of phenomena might be determined by different quadratic forms. Einstein's equivalence principle is therefore an hypothesis only, but an interesting and reasonable one. The author does not, however, consider that a set of equations such as formulated by Einstein and claiming to cover all physical phenomena could be accepted as final, for he considers that the true equations of motion should be capable of accounting for the most important of all physical phenomena, the phenomena of life. Again, in electromagnetic theory, the equations of motion are obtained from the principle that at each instant the integral over the electron of the total force on each element should be zero. And before the equations can be so derived, the design of the electron must be known—the way in which the motions of the differential elements are coordinated, and he questions whether a quadratic differential form in four variables is sufficiently general to specify this. Even then what are regarded as the equations of motion of matter would need supplementing by geometrical considerations specifying the design and organisation of each elementary portion of matter. Then only could the ordinary equations of motion be regarded as a consequence of the electromagnetic laws and the above-mentioned principle. This does not seem satisfactory as a fundamental principle, and might more probably be a consequence of more fundamental principles which are the true equations of motion—and these should indicate the reason for the similarity in design of the electrons. The author feels that the value of the design in relation to the medium, of which this similarity may be regarded as the expression, must be a quantity to be taken into account in the true equations of motion, and have an assigned value at each instant.

It is pointed out that the generalised scheme of electromagnetic relations is not general enough to cover the case of a doubly-refracting crystalline medium, and possible generalisations are suggested; and these emphasise the fact that the absolute calculus of Ricci and Levi Civita can be used to develop a theory of generalised relativity on many lines other than that adopted by Einstein. G. W. DE T.

384. *On the Statistical Spherically Symmetrical Solutions of Einstein's Cosmological Gravitational Equations.* **H. Weyl.** (Phys. Zeits. 20. pp. 31–34, Jan. 15, 1919.)—This paper deals with Einstein's gravitational equations after the introduction of a term containing the constant λ, whereby statistical spherically symmetrical solutions may be obtained. In it the author extends some ideas which he had previously put forward in his book on Space, Time, and Matter, published in 1918. [Abs. 605 (1918) should be consulted.] The paper is mathematical throughout. H. H. Ho.

385. *Relativity Dynamics of the Electron.* **M. N. Saha.** (Phys. Rev. 13. pp. 34–44, Jan., 1919.)—The paper consists of some attempts at developing the point of view set forth in a previous paper by the author [Abs. 1217 (1918)], and includes expressions for the electric and magnetic fields of a moving electron, the Maxwell stresses, the Poynting vector, and the law of attraction between two moving electrons, concluding with a discussion of the equations of motion of the electron. G. W. DE T.

386. *Precession owing to Non-Euclidian Linear Element of Space near the Sun.* **J. A. Schouten.** (K. Akad. Amsterdam, Proc. 21. 4. pp. 533–539, 1919.)—A mathematical treatment on the lines of Einstein's general theory of relativity, and which includes gravitation and other phenomena. The present author finds on this basis that a precession of an obliquely-revolving planet should occur near the sun, this effect being of the same order of magnitude as the deviation of a ray passing near the sun. E. H. B.

387. *On the Hypothesis of the Equipartition of Energy.* **C. V. L. Charlier.** (Ark. för Mat., Astron. och Fysik, Stockholm, 12. No. 18. pp. 1–9, 1917.)—In this paper a proof is given of the above hypothesis which has the advantage of being direct, while not based on the H-theorem, and also is of an elementary character. In section 1 equations are developed for the case of two masses passing each other. In section 2 the special case is treated where the bodies attract according to the Newtonian law. In section 3 the problem is discussed as to whether all values of the angle between the two absolute velocities are to be regarded as equally probable. Although this assumption is manifestly incorrect, yet by taking the average value thereby given, the author demonstrates an interesting example for the illustration of the fundamental hypothesis in the theory of probability that all equally possible cases must be rejected. It is shown that a law is developed very different from that of the equal distribution of energy, namely, that the quicker body always gives energy to the slower, so that the velocities tend to equalise and not the energies. In section 4 it is shown that to obtain correct average values, integration must be performed over all values of the velocity components with respect to the frequency function for these magnitudes. Section 5 deals with the problem when the Newtonian law of attraction is not assumed. H. H. Ho.

388. *Relationships of the de Sitter Coördinate System B to the General World of Constant Positive Curvature.* **F. Klein.** (K. Akad. Amsterdam, Proc. 21. 4. pp. 614–615, 1919.)—The author commences with the spherical case where $\xi^2 + \eta^2 + \zeta^2 - v^2 + \omega^2 = R^2$, and $ds^2 = \pm(d\xi^2 + d\eta^2 + d\zeta^2 - dv^2 + d\omega^2)$, the sign + or — being given according as a space or time vector is

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involved. He then gives the elliptical case. The transition to de Sitter's ds^2 is then made by the substitutions : $\xi = R \sin\theta \cos\phi$, $\eta = R \sin\theta \sin\phi \cos\psi$, $\zeta = R \sin\theta \sin\phi \sin\psi$, $v = R \cos\theta \sinh(ct/R)$, $\omega = R \cos\theta \cosh(ct/R)$. Now $\tanh(ct/R) = v/\omega = u/R$, from which $ct/R = \log\left\{(\omega + v)/(\omega - v)\right\} = \log\left\{(R + u)/(R - u)\right\}$. When $\omega + v = 0$ or $\omega - v = 0$, then $t = -\infty$ or $+\infty$; if both disappear, then t is indeterminate, so that t is only real in the four-dimensional world when $(\omega + v)/\omega - v)$ is positive ; otherwise it is imaginary. ds^2 retains its form with ∞^4 transformations. The author concludes with the remark that his results are only mathematical speculations which may or may not be accepted by the physicist. H. H. Ho.

389. *On the Number of Degrees of Freedom of the Geodetically Moving System, and the Enclosing Euclidian Space with the least possible Number of Dimensions.* **J. A. Schouten.** (K. Akad. Amsterdam, Proc. 21. 4. pp. 607–618, 1919.)—The author commences by defining his system, namely : k is assumed to be a non-special curve in a finite part X_n of a general space of n dimensions, containing no singular points and where only one geodetic line exists between two arbitrary points. If in a point O on k a system of n mutually independent directions be assumed, then the system can be moved geodetically along k. This geodetic moving can be geometrically stated as follows : X_n can always be placed in a Euclidian space of $\frac{1}{2}n(n+1)$ dimensions, without changing its linear element. There exists in this space a space Y_n developable on a Euclidian space of n dimensions, tangent to X_n in k. The geodetically moving directions will now coincide at any moment with the directions moving parallel to themselves in the Euclidian space Y_n. It appears analytically that the known covariant differential of a directed quantity, *e.g.* a vector, is a common differential judged from a geodetically moving system of directions. Hence if V is a vector stationary with respect to this system, V satisfies the differential equation : $dV = 0$, or in coordinates : $dv^\lambda + \left\{ {\mu\nu \atop \lambda} \right\} v^\mu dx^\nu = 0$, and this equation then gives the analytical definition of the notion "geodetic moving." A geodetic line is characterised by the property that its linear element forms at every point the same angles with a system moving geodetically along the line. Starting from a point O, a system of directions is now geodetically moved along a closed curve. On returning to O the system will generally appear to have rotated. Dependent on the choice of the curve it is generally possible to obtain in this manner ∞ positions of the system. If this number is for one point, and hence for every point of the area ∞, N is called the number of degrees of freedom of the geodetically moving system. Three relations are established in the paper, namely : I. The number of dimensions of the Euclidian space, in which a given space X_n may be placed, without changing its linear element, is at most equal to the number of degrees of freedom belonging to the geodetically moving system increased with n. II. If in a general space X_n is placed a system of ∞^{n-p} parallel geodetical spaces of p dimensions P, leaving perfectly perpendicular to it a system of ∞^p similar spaces Q of $n - p$ dimensions, a figure in a definite P-space will be congruently projected by the Q-spaces on all the other P-spaces. III. In the proposition made in formulating II the projection of a geodetic line by means of Q spaces on a P space, or *vice versa*, is, as far as existent, a geodetic one itself. H. H. Ho.

390. *On Four-dimensional Tensor Analysis.* **H. Kafka.** (Ann. d. Physik, 58. 1. pp. 1–54, Jan. 17, 1919.)—Previous analyses, which have regarded invariants in R_4 as geometrical magnitudes of form similar to those in R_3, operate direct with geometrical quantities. These methods of calculation have the disadvantage that in multiplications of several factors an alteration in the association generally results in a change in the multiplicative combination, whereby application is rendered appreciably difficult. This drawback appears to be avoided in the tensor analysis developed by Einstein for the general theory of relativity [see Abs. 858 (1916)]. The latter method has therefore the advantage of rendering possible the treatment of geometrical quantities of any order, and furnishes a mathematical process which combines simplicity with generality. In dealing only with problems concerning the special theory of relativity, the Einstein tensor analysis becomes appreciably simplified. In the present paper a sketch will be given of a tensor theory in which the symmetrical and antisymmetrical tensors are of special significance. Section 2 defines a tensor of the first order as one comprehending four magnitudes and possessing specific transformation properties. In the special relativity theory such a tensor is geometrically represented as a directed line whose projections upon the axes of an orthogonal four-dimensional system of coordinates determine the four magnitudes. In the general relativity theory such a geometrical interpretation is not possible. Section 3 deals with the external multiplication of two such vectors, the result being defined as a tensor of the second order. Section 4 continues the process of multiplication with development of tensors of higher order, and discusses the connection between tensor formation and mode of transformation. In section 5 symmetrical and antisymmetrical tensors of the second order are investigated from the standpoint of the special external multiplications corresponding thereto. Sections 6 and 7 deal with the special tensors of the 3rd order. Section 8 considers special tensors and multiplications of the 4th order. Section 9 investigates an important invariant formation given by tensors above the 2nd order. Sections 10 and 11 discuss inner multiplications. Section 12 deals with supplementary ideas. In sections 5–8 the formation of special tensors, by addition and subtraction of the magnitudes of conjugated tensors, was treated in such a manner that the orders remained unchanged, whereas in section 13, special tensors whose orders can vary are derived by the aid of determinants from tensors of the 2nd and higher orders. Section 14 is concerned with differential operations. Section 15 contains a brief mathematical summary of the more important features of the paper. Section 16 treats of the electrodynamics of empty space according to the special relativity theory. Section 17 deals with the electrodynamics of the ponderable bodies. Sections 18 and 19 derive the strain-energy-tensor for ponderable bodies. The final section investigates four-dimensional force for ponderable bodies.

The paper is mathematical throughout. H. H. Ho.

391. *On Friction in Connection with Brownian Movement.* **O. Postma.** (K. Akad. Amsterdam, Proc. 21. 4. pp. 616–623, 1919.)—The different deductions of the mean displacement of a suspended particle caused by the Brownian movement in a certain time can be divided into two groups. In the first, the forces acting on the particle are divided into accelerating and retarding; in the second kind, this difference is not made. To the deductions of the first group belong those of Einstein, the second one of v. Smoluchowski, Langevin, and de Haas-Lorentz. To the second group belong the first deduction of v. Smoluchowski, and those of van der Waals and

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Snethlage. [See Abs. 12 (1919).] In the theories first mentioned a retarding force (friction) has been assumed proportional to the radius of the particle, which is considered as a sphere and has the velocity v. All theories of the first kind come to the result that the mean square of the displacement ($\overline{\Delta^2}$) is inversely proportional to t and directly to a. The theories of the second kind give the result of $\overline{\Delta^2}$ being proportional to t, and inversely to a^2 and to the density. The resolution of the forces into accelerating and retarding ones is not the cause of these different results, which latter must be ascribed to the assumptions made on the sliding at the surface. The author shows that it is not true that the assumption of a resisting force should be connected with the supposition that there is no sliding. As a rough approximation it is assumed that in a fluid 10^4 molecules are acting at the same time on the particle (of the same order of magnitude as the number that can cover the whole surface), and in a gas 10^2. The collisions which keep the particle in motion are found to be due to accidentally arising complexes of these molecules. In section 2 of the paper, Einstein's formula for the mean distance travelled by a particle is amended to

$$\overline{\Delta^2}=\frac{RT}{N}\cdot\frac{1}{8\pi\zeta a}\,\frac{1+(2\zeta/\beta a)}{1+(3\zeta/\beta a)}\cdot t$$

by means of a formula obtained for the frictional work together with the heat calculated from the dissipation function. In section 3 it is shown that when the work of the resistance is taken into consideration the dissipation function can give the resistance to which the particle is subjected. H. H. Ho.

392. *Instruments for the Measurement of Clouds.* (Engineering, 107. p. 257, Feb. 21, 1919.)—The Besson nephometer for measuring cloudiness consists of a convex mirror mounted at an angle on a horizontal frame. The observer places his eye at a fixed point above, and to one side of, the mirror, which is so chosen that the reflection of the whole sky just fills the mirror. The latter is divided by ruling into ten sections representing equal portions of the celestial hemisphere, and in taking an observation the number of tenths which are covered with cloud is estimated. As some portion of the sky is hidden by the head and shoulders of the observer, it is necessary to take two readings, the apparatus being turned about a vertical axis through 180° between the two. Thus the whole sky is brought under observation.

For determining the height of clouds the following method is due to Bravais :—A small shallow pool of water forms a horizontal mirror at ground-level. The observer stations himself at a suitable elevation, as at an upper window of a building about 10 m. above the ground, and observes the reflection of the cloud (1) in the pool of water, and (2) in a small sheet of plate glass which can be turned about a horizontal axis perpendicular to the line joining the glass to the centre of the pool. The plate glass is rotated by means of a tangent screw until the two images of the cloud become coincident. The height of the cloud can then be calculated from the angle which the plate glass makes with the horizon, the length of the effective base line between the glass and the pool being known. The pool is only a few mm. in depth, and is surrounded by bushes in order to minimise the disturbance caused by wind. J. S. Di.

393. *Meteorology during and after the War.* **H. G. Lyons.** (Soc. Arts, J. 67. pp. 167–177 ; Disc., 177–180, Feb. 7, 1919.)—The author gives an account of the work which has been done by the British Meteorological Services

during the period of hostilities, and refers to some of the different directions in which accurate meteorological reports have proved of great value. Future requirements are discussed with special reference to the demands likely to arise through the development of commercial aviation. In the *discussion*, the hope was expressed that in the future the universities would take a more active interest in the science than they had done in the past. **N. Shaw** pointed out that the only hope of real progress lay in advancement on the scientific side; that is, in obtaining an understanding of the secret processes of weather. J. S. Di.

394. *Variability of Temperature and Rainfall in Berlin.* **O. Meissner.** (Phys. Zeits. 19. pp. 521–524, Dec. 1, 1918.)—A statistical investigation of serial monthly values of temperature and rainfall for Berlin gives the following results:—(*a*) The variability of temperature and rainfall of the official Berlin observations, which have been made since 1848 in accordance with approved practice, is normal. (*b*) The amplitudes of the Brückner period and the sun-spot period in this series of observations are so small in comparison with the irregular variations of shorter period, that they require other methods for their determination. (*c*) The old Berlin observations of temperature made by Kirch from 1730 to 1750, when tested by statistical methods, show no reason why they should be regarded as non-homogeneous. (*d*) The Brückner period of 34 years is well indicated in the temperature observations for Aug. from 1730 to 1750; in winter the periodicity is quite masked by chance variations. R. C.

395. *The Superposition of Aerial Currents in the Peninsula of Cape Verde, Senegal.* **H. Hubert.** (Comptes Rendus, 168. pp. 99–102, Jan. 13, 1919.)—In the interior of western Africa, the normal fall of air-temperature with increase of altitude occurs, whether the surface wind is the monsoon or the harmattan, but on the Senegal coast this rule is not followed when the trade-wind blows. Observations made there in a hydroplane during Oct. and Nov. 1918 show that temperature increases with height, either from ground level or from a height up to about 100 m., until a maximum is reached between 500 and 600 m., which may be as much as 6° C. above the temperature at ground level. As height still further increases the normal fall of temperature again sets in, so that ground temperatures are again met with at heights of 1000 to 1300 m. Relative humidity near the ground is high, but falls rapidly at about 200 m., and reaches a minimum where the temperature shows a maximum.

The observations are explained by the superposition in this season of the dry and hot harmattan east wind above the humid, cool, northerly trade-wind, the plane of contact being below 500 m. It is always possible, however, for the harmattan to descend to the surface, and entirely displace the trade-wind in these months. R. C.

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396. *Meteorology and Aviation.* **C. K. M. Douglas.** (Scottish Meteorolog. Soc., J. 18. No. 35. Nature, 102. pp. 473–476, Feb. 13, 1919.)—This note sets out some of the facts concerning the upper air which have been revealed by observations from an aeroplane. Eddy motion due to surface friction is commonly transmitted up to 3000 ft. or sometimes, when the air is being heated at the surface and the lapse rate is therefore large, to 8000 ft. Such eddy motion is also developed at times in the free air at great heights when the lapse rate is suitable for its propagation. If the humidity is high, a cloud sheet of the alto-cumulus type may in such cases be formed at

the top of the turbulent layer. A region of temperature inversion which forms a "lid" to such a turbulent layer is generally associated with large cloud sheets formed in this way. Cloud sheets with the turbulent layer beneath them may travel for long distances after the original cause of the turbulence has ceased to operate. Instances are quoted where the lapse rate was such that conditions approached instability and towering cumulus clouds developed, one giving rise to a thunderstorm. It frequently happens in such cases that the powerful rising current pushes the cloud up into a region where it is cooler than the surrounding air, in which case it soon sinks down again. As regards visibility it is found that the smoke from factories and towns may travel for hundreds of miles. In winter the smoke usually lies near the ground, but in summer convection currents carry it up 6000 or sometimes 10,000 ft. If there is a temperature inversion above the haze, the top is sharply defined. J. S. Di.

397. *New Method of Reduction of Observations of Underground Temperature.* **K. Aichi.** (Phys.-Math. Soc., Japan, Proc. 1. (Ser. 3). pp. 2–7, Jan., 1919.)—A further discussion concerning the passage of the annual temperature wave downward through the soil, where the conductivity (K) and specific heat (C) vary with depth [see Abs. 240 (1919)]. If temperature observations were available at all depths, K and C could be calculated uniquely as functions of the depth, but actually, where observations at certain specified depths only are taken, a definite solution of the problem is not possible. Various methods of calculating the "equivalent diffusivity" of the layer between two points of observation are discussed and numerical examples are worked out. J. S. Di.

398. *Special Form of the Developments of Integrals in Problem of Three Bodies.* **K. Bohlin.** (Ark. för Mat., Astron. och Fysik, Stockholm, 12. No. 5. pp. 1–97, 1917, and No. 19. pp. 1–115, 1917.) W. W. B.

399. *Prism Astrolabe for Latitude Variation.* **R. Baillaud.** (Comptes Rendus, 168. pp. 85–86, Jan. 13, 1919.)—This is an adaptation depending for its use on the fact that the meridian transits of a star seen directly and by reflection at a prism coincide when the angle of the prism is equal to the altitude of the star. In general, the altitude being not quite equal to the angle of the prism, the images move parallel and the distance between them can be measured with sufficient accuracy to show the effect of latitude variation, since the observation being differential allows of the use of a long-focus objective (up to 20 m.). It is claimed that a latitude variation of 0·1" is easily measurable, even with a 10-m. focus objective. W. W. B.

400. *Whirlpool Cosmogony reconciled with the Special Cases of the Sun and of Novæ.* **E. Belot.** (Comptes Rendus, 168. pp. 158–161, Jan. 20, 1919.)—Taking the case of a body penetrating a nebula, three cases are distinguished, typical of the earth, the sun, and a nova respectively. Among other conclusions are that the 11-year sun-spot period may be the remains of the oscillation of its original nucleus, and that the combined effect of rotation and penetration has caused a precession to which is due the inclination of the sun's axis to the ecliptic. The theory purports also to account for the fluctuations in the brightness of novæ and the displacement of the dark lines towards the violet. An inference is drawn that the equatorial plane in all novæ is approximately that of the Milky Way. The appearance of the nebular line is also explained, and the system is stated to account also for the formation of spiral nebulæ. W. W. B.

401. *Annual Term in Right Ascension.* **M. L. Zimmer.** (Astron. J. 32. pp. 1–6, Feb. 7, 1919.)—This is a preliminary investigation into a discordance noticed in very accurate transit observations, and the conclusions are that there is something not due to the instrument, clock, personal equation, or magnitude equation which causes star transits to be later in the morning than in the evening. This difference is not the same for all stars, and is partly a parallax effect, though too great to be wholly explained in that way. It appears to account to a great extent for the periodic errors of star catalogues, and is in harmony with Chandler's Z-term in latitude variation and with some other conclusions. More data are required, especially in other parts of the sky, so this preliminary notice is given in order to secure these. W. W. B.

402. *Artificial Green Flash.* **G. Coutinho.** (Observatory, No. 536. pp. 80–82, Feb., 1919.)—By experiments with a heliograph, the author has proved that the green flash is a real phenomenon that can be produced by any sufficiently bright light made to skim a sea-surface at the correct height with a range of 20 cm. only, and that with proper adjustment a permanent green light can be seen, if a fixed light is observed instead of the sun. W. W. B.

403. *Perturbations of Neptune's Satellite.* **H. Struve.** (Observatory, 42. No. 535. pp. 55–56, Jan., 1919.)—This is a disclaimer of the hypothesis attributed to the author by Armellini, that the anomalies of motion of Neptune's satellite may be caused by another satellite. Reasons are given for support of Tisserand's hypothesis that the cause is the attraction of the protuberant matter round Neptune's equator. The rotation period is unknown, and depends partly upon whether Neptune is of the type of the earth and Mars—with nearly uniform density—or of the type of Jupiter and Saturn. The necessary flattening comes out at a reasonable value, 1 to 3 %, thus strongly favouring Tisserand's hypothesis. W. W. B.

404. *Cooling of Planetary Globes.* **A. Guébhard.** (Comptes Rendus, 168, pp. 171–174, Jan. 20, 1919.)—The author disputes the generally accepted idea that planets contract in cooling. On the analogy of ice and iron, which expand at the moment of solidification, he points to the formation of a crust as evidence of an expansion of a cooling planet, and claims that the mass will be further augmented by meteoric and other matter swept up in passage through space as by a vacuum cleaner. W. W. B.

405. *Motion of Minor Planets.* **H. v. Zeipel.** (Ark. för Mat., Astron. och Fysik, Stockholm, 12. No. 9. pp. 1–39, 1917.)—Continuation of previous work [see Abs. 210 (1917)]. In this, the third paper of the series, the author investigates the motion of the "commensurable" planets, *i.e.* those in which the ratio of the mean motion to that of Jupiter is approximately $(p+q)/p$, p being prime to q, and q having any other integral value. The long mathematical analysis separates three classes according as $q=1$, $q=2$, or $q=3$ or more, and, further, according to the exactness of the commensurability, which is taken in all cases as within the square root of Jupiter's mass, and in some cases as within the fourth root. W. W. B.

406. *Origin of New Stars.* **J. Bosler.** (Rev. Gén. des Sciences, Nov. 30, 1918. Nature, 102. p. 394, Jan. 16, 1919. Abstract.)—Giving reasons for rejecting radio-activity and direct collision of stars as probable causes of the appearance of novæ, the author declares in favour of Seeliger's hypothesis

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that they are due to the passage of a dark or faint star through an obscure nebula, finding on this basis plausible explanations of all the phenomena noted. He also considers that Wolf-Rayet stars and planetary nebulæ have no place in the evolutionary classification, but are simply the relics of ancient novæ. W. W. B.

407. *Dark Markings of the Sky, with Catalogue of* 182 *such.* **E. E. Barnard.** (Astrophys. J. 49. pp. 1–23, Jan., 1919.)—From a careful and systematic examination of a large number of dark markings in the sky, the author has found himself compelled to give up the idea that they are mostly due to actual vacancies. Arguing from a few conspicuous examples in which the presence of nebulous matter is undoubted, he inclines to the opinion that most of the appearances are due to obscuring matter, much of which is faintly luminous. The preference shown for the Milky Way is, he thinks, only apparent, and due to the brighter background more readily showing up the obscuring patches. Similar patches are found in other parts of the sky, and are shown up by what he thinks may be called the luminosity of space. The forms of obscuring matter resemble bright nebulæ, and several typical ones, photographed with a portrait lens, are reproduced on accompanying plates, others being described in detail. Some have been examined with the great Lick refractor, and the author thinks more ought to be done in this way. The catalogue now given is a first instalment, and contains sufficiently exact places of 182 dark markings for the epoch 1875.0. A more complete list will follow. W. W. B.

408. *Nova Aquilæ No.* 3. **A. C. Gifford, J. T. Ward, C. M. Hector, E. L. Morley.** (New Zealand J. of Science, 1. pp. 352–358, Nov., 1918.)—Notes on the visible spectrum and magnitudes of Nova Aquilæ as observed in New Zealand at the Observatory of Wellington College, at Wanganui, Lower Hutt, and Nelson respectively. Drawings of the spectrum at intervals from June 10 to Aug. 9 are included. W. W. B.

409. *Orbit of the Spectroscopic Binary* 32 θ_2 *Cygni.* **J. B. Cannon.** (Astrophys. J. 47. pp. 193–195, April, 1918.)—32 θ_2 Cygni ($\alpha = 20^h\ 12^m$, $\delta = +47° 24'$; mag., 5.15; type G5) has been known as a binary for quite a number of years. The star has been under observation at Ottawa during the years 1914–1917, during which time 117 plates were taken. The elements are tabulated and curves given embodying the Ottawa and Lick observations and also Küstner's. To explain the curves the system would have to be considered as consisting of a light-giving body revolving about another body in a circular orbit in 890 days, and these two about a third in an elliptic orbit in 1170 days. L. H. W.

410. *Calcium Clouds in the Milky Way.* **J. Evershed.** (Observatory, No. 536. pp. 85–88, Feb., 1919.)—In June photographs of Nova Aquilæ, the author finds a narrow, faint absorption line superposed on emission band H_ϵ and on one plate a similar one at a distance in the ultra-violet corresponding to the interval between the H and K lines of Ca. Allowing for the motion of the earth and of the solar system, he concludes that these are due to nearly stationary calcium clouds. Similar results were found by Campbell and Wright for Nova Persei and by Adams and Kohlschutter for Nova Geminorum (1912), also six binary stars in Alleghany Observatory Publications which show the H and K lines are said to be in accord with zero velocity for the Ca. The author asks for confirmation from other observatories, saying the conditions at Kodaikanal were not very good. W. W. B.

411. *Hydrodynamic Equilibrium of Star Systems.* **C. V. L. Charlier.** (Ark. för Mat., Astron. och Fysik, Stockholm. 12. No. 21. pp. 1–8, 1917.)—The author gives a demonstration, arrived at in 1915, of the following proposition :—If a star system in which the stars are distributed symmetrically about an axis be in equilibrium and the velocity distribution be ellipsoidal, the ellipsoid must be spheroidal with its axis of rotation perpendicular to the radius vector through the centre of the system. This proposition has also been obtained by Jeans, and published in Dec., 1915 [Abs. 814 (1916)], and made the basis of the conclusion that our star system cannot be in equilibrium, a conclusion which the author challenges. According to Schwarzschild, the distribution of star velocities is approximately spheroidal, and the axis of rotation is in the direction towards the so-called *vertex*. The question is whether this direction is perpendicular to the radius vector or not. Jeans assumes the latter, possibly, the author suggests, on the basis of a view put forward, purely hypothetically however, by Turner. According to the author's observations, published in a former report of the Lund Observatory, the former is approximately the case of our star system, so that the non-fulfilment of this condition as an objection to the possibility of our system being one of equilibrium disappears. The author therefore further considers the conditions to be satisfied by the constants of the system of ellipsoids in order that there should be equilibrium, and finds that this is possible only in two cases : (1) if the system be limited to an extent the permissibility of which is very doubtful ; (2) if the axis of rotation be the least axis. Such a system as (2) is not, however, to be found in the Milky Way. G. W. DE T.

412. *Cepheid Variable Problem.* **J. H. Jeans.** (Observatory, No. 536. pp. 88–89, Feb., 1919.)—The author objects to Eddington's pulsation theory, and also to Plummer's physical suggestion of a prominence effect on a large scale. The latter is, he thinks, less conflicting with spectroscopic evidence, and he hopes that explosions or tidal eruptions on a rotating body will prove to be a satisfactory modification. He finds that simple relations between period of rotation and light-variation will cover Phillips' two groups of long-period variables as well as the Cepheids, and thinks that the physical cause is the same for both sets of variations, the explosions being in the nature of forced, and not free oscillations. [See Abs. 874 (1917).] W. W. B.

413. *Colours and Magnitudes in Stellar Clusters.* IX. **H. Shapley.** (Mt. Wilson Solar Observat., Contrib. No. 154. Astrophys. J. 49. pp. 24–41, Jan., 1919.)—This is a continuation of a series on this general subject [for No. VIII. see Abs. 1289 (1918)], and contains three notes on Cepheid variation : (1) Relation of period to luminosity ; (2) Composite colour-curve of 108 cluster-type variables ; (3) Relation of colour to period for the same class. There is a preliminary note explaining why Cepheid variables are preferred for the purpose of obtaining the distances of globular clusters, rather than the red giants or the B-type stars, and the following conclusions are drawn by the author from this stage of the work :—(1) The redder a Cepheid variable is, the greater its intrinsic brightness ; the relation between colour-index and absolute magnitude being nearly linear. (2) The general characteristics of the luminosity-period curve of Cepheid variation are reasonably explained on the pulsation hypothesis. (3) The giant stars in at least four globular clusters show a decrease of brightness with decrease of colour-index, similar to that shown by Cepheids, but the variable ones are about 0·4 of a magnitude bluer than other giants. (4) A composite colour

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curve for the 108 cluster-type variables is derived from two pairs of photographs of Messier 3. (5) The range of variation, form of light-curve, and phenomena of colour variation in globular clusters are just like those of the average isolated cluster-type variable. No evidence is found of any systematic difference between Cepheids of different systems. (6) In Messier 15 there are two sub-classes of cluster-type variables of distinctly different mean period; they show no difference in mean magnitude or in colour at the time of mean magnitude, but at maximum the stars of shorter period are slightly bluer. (7) Preliminary investigation of violet magnitudes of cluster-type variables show smaller amplitude than in photographic light. For giant invariables of clusters the difference, Violet minus Photographic, increases with colour-index and hence also with photovisual magnitude. W. W. B.

414. *Absence of Globular Clusters from Mid-galactic Regions.* **H. Shapley.** (Observatory, No. 586. pp. 82–84, Feb., 1919.)—This gives a diagram to prove that the absence of globular clusters from the neighbourhood of the galactic plane [see Abs. 650, 651 (1918)] cannot be explained by obscuration due to dark nebulosity; and gives reasons in support of the reality of the phenomenon discussed. W. W. B.

415. *Star with Disappearing Bright Lines.* **E. B. Frost.** (Astrophys. J. 49. pp. 61–62, Jan., 1919.)—The star Boss 5918, announced recently by J. S. Plaskett as having variable radial velocity, has been re-examined at Yerkes Observatory, and found to have lost the bright fringes on each side of H_β which it showed in 1918. Particulars are given of Harvard photographs of the same star in 1887 and some intervening years. This kind of variation is rarely noted. W. W. B.

416. *Distances and Velocities of the Stars of Spectral Class F.* **C. F. Lundahl.** (Ark. för Mat., Astron. och Fysik, Stockholm, 11. No. 30. pp. 1–22, 1916–1917.)—The author recapitulates the formulæ and mean errors occurring in Charlier's method for determining the distances and velocities of stars with known proper motions and magnitudes (Astron. Nachr. 4801). Numerical results are given of applying this method to stars of the sub-classes F0, F2, F5, and F8, certain stars being rejected for reasons stated. The approximate density, about the sun, of stars of spectral class F is deduced as 0·1289 stars per cubic siriometre [1 siriometre $= 10^6$ Astr. units]. A comparison is given between the observed and computed parallaxes of about 40 stars of spectral class $\leqq 5{\cdot}99$, the observed parallaxes being on an average greater than the computed ones; this is because those stars for which parallaxes are observed have either great luminosity or large proper motion, and both features indicate a relatively small distance. The second part of the paper deals with the determination of the velocity ellipsoid from the star's galactical velocity components, and the third part with the velocity distribution in the plane of the galaxy; the formulæ do not lend themselves to concise condensation. It seems that the stars' velocities should increase with increasing distance from the centre of the galaxy, but the mean errors render the validity of this conclusion doubtful. H. F. H.

LIGHT.

417. *Fringes at Boundaries of Diffracting Apertures seen by Diffracted Light only.* **S. Banerji.** (Phil. Mag. 37. pp. 112–128, Jan., 1919.)—The paper, which was suggested by a recent one by Rayleigh [Abs. 678 (1918)], deals with the luminous fringes seen when apertures of various shapes are viewed through a telescope focused on its plane, the object glass being covered by a screen containing one or more apertures through which diffracted light enters the field of view. Two plates of very beautiful photographs show the general character of the results observed, and a case in which the central part of the field at the focal plane is blocked out by a circular disc, and only the diffracted rays passing through an annulus surrounding it enter the observing telescope, is worked out mathematically in detail. An interesting result is that in all cases in which the apertures in the focal plane through which the rays pass are symmetrically disposed about the centre of the field, the centre itself being excluded, the image of the boundary of the diffracting surface appears as a perfectly black line surrounded on either side by luminous bands. A similar result is observed when the screen with the apertures is placed symmetrically in any plane either before or behind the focus. Narrowing the apertures is, however, attended by an increase in the width of the black line and the appearance of a number of well-defined fringes. This feature may be accounted for by Sommerfeld's classical analysis if we regard each element of the edge of the aperture as emitting two streams of light in opposite phases, one on each side of the wave-normal.
G. W. de T.

418. *Diffraction of Light by a Semi-infinite Screen.* **S. K. Mitra.** (Phil. Mag. 37. pp. 50–61, Jan., 1919.)—Sommerfeld, who first obtained a complete solution of this problem [Math. Annal. 47. p. 317, 1895] and Drude have assumed that Kirchhoff's formula should give the value of the intensity of illumination with sufficient accuracy when the angle of diffraction is small. The author finds, however, that an examination of the formulæ shows that when the light is incident very obliquely on the screen the approximation given by Kirchhoff's formula fails to represent the facts correctly even in regard to small angles of diffraction. This conclusion is confirmed by photometric results given in the paper, and the experiments led further to the discovery that in the case of light polarised perpendicularly to the plane of incidence the boundary conditions of the screen assumed by Sommerfeld lead to results differing widely from the observed optical behaviour of any actual screen at very oblique incidences. The author suggests a modification in the assumed boundary conditions which secures agreement with observation in the case of very oblique incidence.
G. W. de T.

419. *Theory of Superposed Diffraction Fringes.* **C. Prasad.** (Phys. Rev. 13. pp. 27–33, Jan., 1919.)—The present paper is concerned with observations recorded first by Brush, some of whose work has been further investigated and explained in an entirely different manner by Basu [Abs. 868 (1918)]. The effects here dealt with are those produced by a row of straight-edges placed in echelon order. It is shown that the principle of superposition suggested by Brush may be formulated mathematically, and its validity tested by experiment. The results obtained with systems of two or more

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edges are in good agreement with the theoretical formulæ. Photographs and diagrams are given. A. W.

420. *Influence of Temperature on the Transmission-factor of Coloured Glasses.* **M. Luckiesh.** (Frank. Inst., J. 187. pp. 225–226, Feb., 1919.)—The transmission-factor for total visible radiation is studied for a variety of glasses (copper, cobalt, gold, manganese, chromium, etc.). In every case except two there was a marked diminution in the transmission-factor with a temperature increasing from 30° to 350° C., the greatest change, for a copper glass, being from 100 to 42. The two exceptions were cobalt glasses. In one case there was no appreciable change, in the other the transmission-factor increased from 100 to 108. Colour differences with rising temperature were also encountered, being greatest for two specimens containing respectively Cu and Cr for temperatures above 100° C. J. S. D.

421. *Astigmatism: Interchangeability of Planes of Stop and Object.* **T. Chaundy.** (Optical Soc., Trans. 20. pp. 11–16; Disc., 16–17, Oct. 1918.)—Considers the case of a coaxial optical instrument through which passes a beam of light issuing from an object point near the axis of the instrument. The beam is supposed to be restricted to a small angle by the insertion of a stop at some point of the axis, and the diam. of this stop and the distance of the source from the axis are small. The paper obtains, by the method of line coördinates [see Abs. 53 (1918)], the conditions that must be fulfilled in order that an interchange of the planes of the source and the stop may leave the astigmatism unaffected. J. W. T. W.

422. *Crystallography.* **F. Grandjean.** (Comptes Rendus, 168. pp. 91–94, Jan. 13, 1919.)—Describes the method which may be employed for calculating the path of the extraordinary rays for certain structures of anisotropic liquids [see Abs. 709 (1918) and 179 (1919)]. A. W.

423. *Optical Character of some Brilliant Animal Colours.* **Rayleigh.** (Phil. Mag. 37. pp. 98–111, Jan., 1919.)—In this paper the author gives a review of the arguments which have been advanced in favour of (i) the "structure-colour" theory, and (ii) the "surface-colour" theory of the origin of the brilliant colours displayed by many birds (*e.g.* humming-birds), butterflies, and beetles. Much still remains to be effected towards a complete demonstration of the origin of these colours, though the evidence appears to support the view that the colours have their origin in interference phenomena rather than in surface colouration. A. W.

424. *Symmetrical Optical Instrument.* **H. C. Plummer.** (Roy. Irish Acad., Proc. 34. pp. 67–84, Jan., 1919.)—Extends Schwarzschild's treatment of the errors of an optical instrument, on the basis of the Eikonal, to an examination of the errors to a second order of approximation. The paper is mainly mathematical and cannot be usefully abstracted. J. W. T. W.

425. *Motions of Illuminated Particles of Sulphur and Selenium with and against the Light.* **I[rene] Parankiewicz.** (Ann. d. Physik, 57. 7. pp. 489–518, Dec. 20, 1918.)—An elaborate investigation, the account of which abounds in tables and graphs. The order of magnitude of the sulphur particles is estimated from their colour and limiting falling speed. The motions under illumination (*der photophoretische Effect*) of sulphur particles are investigated for different gas pressures. Graphs are plotted showing the optical resonance of those sulphur particles. The corresponding motions of particles of selenium were also examined quantitatively. The effects in question for selenium are in some circumstances with, and in others against the light (*lichtpositiv* and *lichtnegativ*); for sulphur they are always against the light. The *light-negative* force on the particle is about six times that of the same rays on sulphur particles of equal mobility. The intensity with which particles of the same materials react on the light is dependent on the size of the particles. The light-negative effect reaches a maximum for sulphur particles of radius 27×10^{-6} cm. and for selenium particles of radius 15×10^{-6} cm. Other points are also discussed. [See Abs. 1085 (1918).]

E. H. B.

426. *A New Photographic Transfer Process.* **T. P. Middleton, F. W. Kent, and W. B. Ferguson.** (Phot. J. 59. pp. 42–45, Feb., 1919.)—The ideal transfer process should be one in which (1) the support is textureless and translucent, so that printing-through should be possible without much loss of detail or prolonged exposure; (2) the support is little affected by damp, so that register might be possible of one image on another, and yet sufficiently porous to permit of the use of aqueous adhesives to transfer on to non-porous surfaces; (3) the support is without tendency to tear, and sufficiently plastic to admit of transfer on to a domed or curved surface; (4) the emulsion parts with facility when transferred, and is yet so adherent that there is no danger of filling or blistering in development or of self-stripping when stored; (5) the prints when made would be capable of being kept before transference for as long a period as might be necessary; and (6) double transfer on to any surface is simple and easy, so as to avoid lateral reversal which could not be escaped unless printing-through is adopted. A long series of experiments has shown that paper impregnated with paraffin wax most nearly fulfils the first three of these conditions, and subsequently a substratum consisting of powdery nitrocellulose deposited from an aqueous ethereal alcoholic solution was devised, and this enabled any sensitive gelatinous material to be coated thereon, thereby satisfying the three latter conditions. The paper is prepared continuously, *i.e.* it is put in as a reel of ordinary plain photographic paper, passed through a trough full of hot wax, and after buffing or calendering in order to lay the hairs down again while the wax is still warm, is coated with the substratum. This is passed through a heated chamber, where the air is exhausted, and is finally coated with ordinary photographic emulsion in a coating machine.

Kerotype paper, as it is called, is made in three degrees of speed: slow bromide for contact prints, rapid bromide for enlargements, and gaslight. The printing, exposing, and developing of the paper differs in no way from that of ordinary bromide or gaslight, and as to washing, owing to the impervious and temporary nature of the support, seven minutes in running water is ample to ensure permanency.

A. E. G.

427. *Brightness of a Black Body and Mechanical Equivalent of Light.* **E. P. Hyde, W. E. Forsythe, and F. E. Cady.** (Phys. Rev. 13. pp. 45–58, Jan., 1919.)—Describes the determination of a new set of values of the brightness of a black body from 1700° to 2600° K., assuming a temperature scale based on Planck's equation and taking the gold point as 1336° K., and the constant C_2 as 14,350 μ deg. These values are plotted on a curve obtained by the least-square solution and are compared with the relative computed

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values on the assumption of the visibility curve obtained by the authors. The brightness of the black body at a temperature of 2077° K. (colour-match with 4 w.p.c. standard carbon lamps) is calculated as 70·2 candles per cm.^{2}, and this is proposed as an absolute standard of light. The mechanical equivalent of light for the wave-length of max. visibility ($\lambda = 0{\cdot}566\,\mu$) is computed to be $0{\cdot}00150 \pm 0{\cdot}00005$ watt per lumen, and the Crova wave-length at 2000° K. is found to be $0{\cdot}578\,\mu$. J. W. T. W.

428. *Fizeau's Experiment and the Ether.* **R. A. Houstoun.** (Phil. Mag. 37. pp. 214–219, Feb., 1919.)—Fizeau accounted for his 1859 experimental result on Fresnel's assumption that the ether in the tube was dragged with the water with a velocity $v(1-1/\mu^2)$, where v is the velocity of the water. Michelson and Morley repeated Fizeau's experiment with greater accuracy in 1886, and confirmed his result. But according to Lorentz's theory of 1895, the velocity of the ether drift in the tube should be given by $v(1 - 1/\mu^2 - \lambda d\mu/\mu d\lambda)$, and in 1915 Zeeman, using very refined methods, verified the existence of the new term and its variation with the wave-length. The author observes that it has hitherto been assumed that this expression is derivable only from the electron theory or from the relativity equations, but he here shows that it is derivable on the bases of the older elastic theories of light on the assumptions that inside matter there are particles attached to points in the ether and executing vibrations about them, and that in the coefficient of v, c/μ may be written for the velocity of light within the tube. The author claims, as the result of his discoveries, that his theory, having equations and boundary conditions formally identical with those of the electromagnetic theory, will, if such system of equations be coupled with a dispersion theory of the type given by Maxwell or Sellmeier, apparently do all that the original Lorentz theory does for moving media, and more simply. In common with the latter it accounts for aberration and the null effect of the earth's motion through space on all optical observations to the order v/c, and in common with it would require the Fitzgerald-Lorentz contraction—or some alternative—to account to the order v^2/c^2, for the null effect in the Michelson-Morley experiment. On the assumption of an elastic ether he claims that the alternative offers of assuming that the ether participates in the earth's translation but not in its rotation. But this involves his further claim that it is legitimate to consider the ether as attached to our own planet and to judge his hypothesis solely with respect to its capacity to account for actual observations. **O. J. Lodge.** (Phil. Mag. 37. p. 315, March, 1919.)—Referring to Houstoun's paper, Lodge, under the title "Ether and Motion," remarks that the supposition that the ether can be attached to the earth involves so many fundamental difficulties as to make it an unattractive hypothesis—one, moreover, which he considers definitely negatived by his experiments [Phil. Trans. 184. p. 727, 1893, and 189. p. 149, 1897] in conjunction with the Michelson-Morley experiment, which combined compel us to regard the Fitzgerald-Lorentz contraction as a reality. He dissents from the view to which Houstoun appears to incline, that to admit this contraction involves admitting in full the negations of the Relativity Principle, and considers that we should continue to seek, with hope of early success, for experimental evidence of motion through the ether. He notes with approval that Houstoun's procedure shows his agreement with his own view that Fizeau's experiment does not show motion of ether within a transparent medium. It does show that the main body of the ether does not move, what does move being the ethereal modification of loading responsible for lessening

the velocity of light inside matter—the extra Kμ, in fact, belonging to the matter. If some function of these constants other than their product could be determined, our knowledge of the ether should forge ahead. G. W. DE T.

429. *Origin of Radiation in the Tube-Resistance Furnace.* **A. S. King.** (Mt. Wilson Solar Observat. Contrib. No. 162. Astrophys. J. 49. pp. 48–58, Jan. 1919.)—Hemsalech [Abs. 1159 (1918)] has reached conclusions with regard to the origin of radiation in the tube-resistance furnace which differ materially from the views advanced by the present author.

In this paper the author criticises Hemsalech's work, and describes experiments which tend to show that for the high-temperature lines of iron, for the production of the iron spectrum without a potential gradient, and for the spectra of copper and silver in the tube-furnace, some feature of Hemsalech's experiments has prevented the observation of spectrum lines which can nevertheless be produced under conditions which apparently invalidate the conclusions Hemsalech draws from his results. Hemsalech's work has done much to show the importance of possible chemical actions, and this feature of the furnace radiation deserves to be taken into account at every point. A. W.

430. *Infra-Red Arc Spectrum of Iron.* **H. M. Randall and E. F. Barker.** (Astrophys. J. 49. pp. 42–47, Jan., 1919.)—In the work described a 6-in. flat grating, 15,000 lines per in., was employed. The iron was over 99·8 % pure, the largest single impurity being Cu, about 0·04 %. The results were checked by using also some electrolytic iron. A table is given of the wave-lengths and relative intensities of about 50 lines, the wave-lengths ranging from 9000 to 26,727 Å.U. [See Abs. 64 (1918).] A. W.

431. *Infra-Red Arc Spectra of Co, Ni, Mn, and Cr.* **H. M. Randall** and **E. F. Barker.** (Astrophys. J. 49. pp. 54–60, Jan., 1919.)—The experimental arrangements and methods in this work were the same as for similar work on the iron arc [see preceding Abs.]. The materials used were the ordinary metals of commerce. Tables are given of 23 lines in the spectrum of Ni, from λ8967 to λ18,040, 28 lines in the Co spectrum, from λ9096 to λ19,779, 28 Mn lines, from λ8672 to λ17,608, and 41 lines in the spectrum of Cr, from λ8947 to λ26,232. The values when not otherwise stated are probably accurate to within one or two Å.U. A. W.

432. *Series Formula for Line Spectra.* **A. M. Johanson.** (Ark. för Mat., Astron. och Fysik, Stockholm, 12. No. 6. pp. 1–92, 1917.)—The author gives a new formula for spectral series, which in the case of series already well represented by a series formula gives equally as good agreement with observed wave-lengths, and which also represents with a high degree of accuracy many series which up to the present showed marked discrepancies between observed and calculated wave-lengths for certain lines (usually at or near the beginning of the series). The formula in its simplest form may be written

$$\nu_m = A - 4N/\left[\left\{(x+m)^2 + a\right\}^{1/2} + \left\{(x+m)^2 + b\right\}^{1/2}\right],$$

where A is the limit of the series, N is Rydberg's constant, and x, a, b are other constants, m taking the values 0, 1, 2, 3 ... The formula is applied to series in the arc spectra of H, He, Li, K, Rb, Cs, Zn, Cd, Hg, Al, In, Tl, and Mg, and in the spark spectra (enhanced lines) of Mg, Ca, Sr. Tables are given in all cases. A. W.

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433. *Structure of Band Spectra.* **T. Heurlinger.** (Ark. för Mat., Astron. och Fysik, Stockholm, 12. No. 4. pp. 1–7, 1917.)—Following up Bjerrum's work, in which he shows how the rotation of the molecule and the oscillation of the atoms of the molecule may account for the ultra-red absorption bands of gases, the present paper shows that the same or similar suppositions may account for the structure of certain bands. The bands dealt with are the mercury bands λλ4219, 4214, 4017, 4012, 4011, the copper bands λλ4279, 4005, and the so-called cyanogen band λ3883. A. W.

434. *Ionisation and Resonance Potentials for Electrons in Vapours of As, Rb, and Cs.* **P. D. Foote, O. Rognley,** and **F. L. Mohler.** (Phys. Rev. 13. pp. 59–70, Jan., 1919.)—A continuation of previous work [Abs. 941 (1918)]. It is shown here that two types of inelastic collision between the electron and atom occur in vapours of As, Rb, and Cs. The p.d.'s through which an electron must fall to attain sufficient energy or velocity to produce these collisions are in the case of Rb and Cs determined by the quantum relation $h\nu = \mathrm{V}e$, where, for the resonance potential, ν denotes the frequency corresponding to the first doublet of the principal series, and for the ionisation potential ν denotes the convergence frequency of the principal series. Experimentally determined values of the resonance and ionisation potentials for Rb were 1·6 volts and 4·1 volts respectively; for Cs, 1·48 volts and 3·9 volts; and for As, 4·7 volts and 11·5 volts. By applying the quantum relation to the results for As, we are able to predict the presence of an undiscovered spectral series in the arsenic spectrum having its first term (or terms if a doublet series) near λ2620 and converging near λ1070. A Wehnelt-tube discharge in As possesses no luminosity, indicating that the important series lines lie in the ultra-violet. At the ionisation potential of Rb and Cs the principal, first, and second subordinate series appear. No ionisation whatever could be detected at the resonance potentials of the three elements. A. W.

435. *Ionisation and Excitation of Radiation by Electron Impact in Nitrogen.* **B. Davis** and **F. S. Goucher.** (Phys. Rev. 13. pp. 1–5, Jan., 1919.)—The apparatus and experimental details employed in this work were essentially the same as those used for mercury vapour and hydrogen [Abs. 1278 (1917)]. The results show that there is a marked increase in the radiation (starting at 7·5 volts) at about 9 volts, the curves being very steep after this voltage. One curve, obtained with a very small emission from the source and at low pressure, shows the above effect to be largely due to radiation up to a value of about 17·5 or 18 volts. At this voltage the curve rises rapidly in spite of the opposing field used in this case, showing that ionisation has set in. Hence the ionisation potential for nitrogen is about 18 volts—a value considerably higher than hitherto supposed, but more in accord with Johnson's work. The intense radiation produced at about 9 volts is of interest in connection with the work of Meyer, who found that the wavelength about 1300 Å.U. stimulated the fluorescent band 3064 Å.U. in nitrogen. The value 1300 Å.U. from the quantum relation $\mathrm{V}e = h\nu$ would correspond to a voltage of the order of 9 applied to an electron. A. W.

436. *On "Economy" in X-ray Spectroscopic Methods.* **H. Seemann.** (Phys. Zeits. 20. pp. 51–55, Feb. 1, 1919.)—The author shows how it is possible by a judicious arrangement of slits, screens, and crystal in X-ray spectrometry to obtain a bright, sharp spectrum, whilst making the fullest possible use of the X-ray energy emitted from the source.

A modification of Rutherford's spectral-method for γ-rays is described, whereby a sharp spectrum of short-wave X-rays can be obtained by reflection from, or transmission through, a thick crystal. A. B. W.

437. *New Spectroscopic Method.* **W. Friedrich** and **H. Seemann.** (Phys. Zeits. 20. pp. 55–61, Feb. 1, 1919.)—A modification of the Rutherford transmission method has been developed, making use of the principles proposed by Seemann [see preceding Abs.]. The method is applied especially to the case of very hard X-rays. A. B. W.

438. *Energy of the Characteristic X-ray Emission from Molybdenum and Palladium as a Function of Applied Voltage.* **B. A. Wooten.** (Phys. Rev. 13. pp. 71–86, Jan., 1919.)—In studying the K-series characteristic X-radiation of Mo and Pd, it was found that in each metal the α- and β-radiation appeared at a certain voltage. For Mo this voltage was found to be 19·2 kv., and for Pd it was 24 kv. For Mo this measured critical voltage is almost exactly that required by the Planck hypothesis to produce the β-line. For Pd the measured critical voltage is that required by the same hypothesis to produce a wave-length slightly shorter than the β-line [see Abs. 1046 (1916)]. Curves are plotted showing the relation between the voltage squared and the intensities of the α- and β-radiation for both metals, and these curves show that the intensities of these radiations vary directly as the square of the voltage for voltages not too near the critical values. The ratio of the intensity of the α-line to that of the β-line for each metal was found to become constant as the voltage was increased. The straight-line parts of the curves, if produced, cut the voltage-squared axis in the same point, and this point was found to bear the same relation to the atomic number of the metal of the antikathode that the point at which the curves themselves cut the axis bears, *i.e.* the square root of the coordinate represents a voltage proportional to the square of the atomic number of the radiator. Absorption coefficients of the α- and β-lines of Mo and Pd in glass, Mo, and Pd respectively were determined, and were found to vary approximately as the cube of the wave-length of the radiation [see Abs. 682 (1918)].

By application of the theory of B. Davis [Abs. 1097 (1918)] it was possible to calculate the ratio of the intensity of the α-radiation to that of the β-radiation as given by a single atom. The curves obtained by plotting the theoretical equation were found to agree excellently with the experimentally determined curves; the observed intensities of the α- and β-lines for each metal were corrected for absorption in the glass of the X-ray tube. E. A. O.

439. *Absorption of X-rays.* **T. E. Aurén.** (Phil. Mag. 37. pp. 165–207, Feb., 1919.)—The author has determined the relative absorption coefficients of X-rays in a large number of different elements by the compensation method described in a previous paper [Abs. 961 (1917)]. The additive law, namely, that the absorption of a molecule is additively determined by the absorption of its constituent atoms, was found to be accurately obeyed in the case of the chemical compounds examined. With the possible exception of carbon, the state of aggregation appears to have no influence on the quantity of absorption. In chemical compounds containing the same element in different valencies, no difference in the absorption by that element could be ascertained. The relative atomic absorption coefficients of most of the elements between H and Pb were determined for the four mean wave-

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lengths 0·88, 0·86, 0·84, and 0·80 × 10^{-8} cm. Assuming that the absorption of H is exclusively due to scattering produced by the electron combined with the atomic nucleus, scattering for other elements has been found likely to be due solely to the electrons constituting the outer layer of the respective atoms, *i.e.* to the "outer electrons," and by aid of the relative atomic absorption coefficient of H, the number of the outer electrons has been estimated for the lighter elements. The atomic absorption coefficient increases for different elements by groups nearly proportionally to the atomic number. If the atomic number is taken as the number of electrons combined with the atomic nucleus, it is possible from the increase of absorption with increasing atomic number to determine the distribution of electrons between the outer and inner region. From the determination of μ/ρ for Cu and H_2O made by Barkla and White [Abs. 166 (1918)], a formula has been deduced for the mass scattering coefficient of different elements. The value of the mass scattering coefficient of Al for γ-radiation, calculated by this formula, agrees very well with the experimentally observed value.

The number of the outer electrons in the lighter elements seems to be the same for the elements placed in the same vertical row of the periodic system; and the distribution of electrons thus appears to have close connection with the periodicity of the chemical qualities of the elements as expressed by this system. E. A. O.

440. *Investigations on X-ray Spectra. On the Measurement of Planck's Quantum* h *by the "Minimum Potential" Method.* **E. Wagner.** (Ann. d. Physik, 57. 6. pp. 401–470, Dec. 13, 1918.)—After considering the various methods of determining h and comparing results obtained by widely different methods, the author gives a detailed description of the "minimum potential" method. Using Einstein's quantum equation $eV_0 = h\nu$, Duane and Hunt [Abs. 1419 (1915)] obtained a value for h of $6{\cdot}50 \times 10^{-27}$ erg. sec., V_0 being the "minimum potential" necessary to produce X-rays of frequency ν. Millikan's value of e was assumed correct.

The author now describes in great detail a similar determination, special precautions as regards divergence of X-ray beam, slit width, etc., being taken to obtain a *sharp* beginning of the continuous X-ray spectrum. The results of the investigations are included in the following table, where the author compares his value with those of other investigators:—

	$h \times 10^{29}$ erg. sec.	Antikathode.	Range of Voltage	Method.
Duane-Hunt	650	Tungsten	25,000 – 40,000	Minimum Potential
Webster	653	Rhodium	20,000 – 40,000	
Wagner	649	Platinum and Copper	4600 – 10,600	
Millikan	656	Photoelectric limiting potential		
Warburg-Muller ... (Millikan e)	654	according to Planck's radiation equation		
Rydberg. Const. R.... (Millikan e)	654	according to Bohr's spectrum formula		

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441. *Experimental Investigation of X-ray Spectra—"M" Series.* **W. Stenström.** (Ann. d. Physik, 57. 5. pp. 347–375, Nov. 26, 1918.)—Using the

Bragg X-ray spectrometer, the author has made an elaborate examination of the "M" spectra of a large number of different elements. The results are included in a series of tables.

The original paper should be consulted. A. B. W.

442. *X-ray Analysis and the Assignment of Crystals to Symmetry Classes.* **A. E. H. Tutton.** (Washington Acad. Sci., J. 9. pp. 94–99, Feb. 19, 1919.) The author draws attention to a memoir on the above subject by E. T. Wherry, *Ibid.* 8. pp. 480–486, Aug. 19, 1918, which he claims is based on misconceptions regarding fundamental facts of a type which is becoming increasingly common among the workers and writers on X-rays and crystals. The final conclusion of the memoir in question is that both the symmetry of the space-lattice as a whole, and that of the crystal molecules or unit cells of the space-lattice, may find expression in significant physical features and that both should be taken into account in the assignment of crystals to symmetry classes, even though it may be necessary at times to state two different classes for the same crystal. The author accepts the first portion of this conclusion provided it be kept clear as a fundamental fact that it is the space-lattice that determines the crystal system and the obedience to the law of rational indices, while it is the structural detail represented only by a point in the space-lattice that determines what particular one of the 32 classes of possible crystal symmetry is developed. But with respect to the last sentence of the conclusion, *i.e.* that a crystal can be allocated to two different classes, he contends that it is absolutely and fundamentally wrong and entirely unacceptable. A structure either possesses the elements of symmetry of a particular class or it does not; there is no half-way house.

Another misconception pointed to in the memoir is that a space-lattice can be anything but holohedral. There are only 14 space-lattices, verified by Bravais, and *all* are essentially and necessarily holohedral. They are too simple to be anything else. Point systems corresponding to crystal classes of lower than the full systematic symmetry are not space-lattices at all, but Sohncke regular point systems. As the space-lattice is always holohedral it is pointed out that the suggestion made in the memoir would, if carried out, result in every substance belonging to a class other (lower) than the holohedral class of the system to which it conforms, being relegated not only to that subsidiary ("hemihedral" or "tetartohedral") class in question, but also to the holohedral class of the system, *i.e.* to two different classes of the same system possessing quite different elements of symmetry, which is absurd. The author emphasises the fact that the space-lattice only determines the crystal system and not the class. It expresses the grosser structure, that of the molecules or polymolecular groups, each point or node of the lattice representing a single molecule or the small group of two, three, four, etc., molecules necessary to the complete crystal structure. It is the whole structure including the detailed arrangement of the atoms in the molecule or group which determines the class.

E. T. Wherry (*Ibid.* pp. 99–102, Feb. 19, 1919.)—Wherry summarises his reply to the above criticism as follows: In the paper under discussion, the writer assembled the data for a number of crystals, in the assignment of which to symmetry classes one method of study gives results which conflict with those of other methods of study. He presented an interpretation of the relations which appeared to him capable of reconciling these discordant results, involving the new conception that crystals may belong to one

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symmetry class with respect to some properties and to another class with respect to other properties. Tutton apparently feels that the present views of crystallography are adequate to explain all past (and future) crystallographic observations. Rather than recognise that diamond, pyrite, etc., belong simultaneously to two different classes depending on what property is considered, he prefers to ignore observations which do not accord with the one of these symmetry classes which for one reason or another he wishes to accept for each substance. In diamond, he overlooks the class 31 habit and etch-figures, in pyrite the class 28 habit and electrical phenomena, and so on. The writer does not believe that ignoring results which do not suit a preconceived theory is the proper scientific spirit, and prefers to modify or revise current ideas when necessary to explain undeniable observational facts, even though this may lead to his being accused of putting forward "speculations built on incorrect crystallography." It is further pointed out that the view that molecules rather than atoms occupy the points or nodes of space-lattices has been rather definitely disproved by the very X-ray study of crystals which started the present discussion. E. A. O.

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443. *Determination of the Half-value Periods of Thorium and Actinium Emanations.* **R. Schmid.** (Akad. Wiss. Wien, Ber. 126. 2a. pp. 1065–1079, 1917. Comm. No. 103 from the Inst. f. Radiumforschung.)—After referring to the work of Leslie and Perkins [Abs. 436 (1913), 1274 (1914)] the author describes a method which is the same in principle as that used by these experimenters. Measurements were also made by Rutherford's method, in which the ionisation current is measured at different points of a tube through which the emanation flows at a known rate. A third method employed is that due to Mache.

The mean results of the investigations are as follows:—

Half-value period for:
Thorium emanation ... ... $T = 54{\cdot}5 \pm 0{\cdot}03$ secs.
Actinium „ ... ... $T = 3{\cdot}92 \pm 0{\cdot}015$ secs.

A. B. W.

444. *Chemical Action of Penetrating Radium Rays; Influence of these Rays on Chloroform and Carbon Tetrachloride, with a Note on the Action of U.V. Light on Chloroform.* **A. Kailan.** (Akad. Wiss. Wien, Ber. 126. 2a. pp. 741–756, 1917. Comm. No. 101 from the Inst. f. Radiumforschung.)—Chloroform and carbon tetrachloride are radiated by the γ-rays from 80 mgm. of radium salt. The chemical changes taking place are observed for different times and conditions of exposure. The formation of hexachlorethane, carbon tetrachloride, HCl, and Cl_2 by radiating $CHCl_3$ is demonstrated. Various other carbon-chlorine compounds (C_2Cl_6 and $COCl_2$) are produced when CCl_4 is radiated.

A note is added on the action of ultra-violet light on chloroform. It is shown that C_2Cl_4 is found in the reaction which takes place. A. B. W.

445. *The Age of Thorium Minerals.* **R. W. Lawson.** (Akad. Wiss. Wien, Ber. 126. 2a. pp. 721–789, 1917. Comm. No. 100 from the Inst. f. Radiumforschung.)—The paper commences with a discussion of the work of Soddy [Abs. 1585 (1905) and 810 (1917] and of Hönigschmid [Abs. 511 (1917)] on the end-product of the thorium series. This is followed by a consideration of the various determinations of the atomic weight of thorium lead and its bearing on the life of the thorium minerals. It is shown that the age, determined from the Th/U and Pb/U ratios may be between 8 and 800 million years, the minerals being taken from Devon, Brevig, and Norway. The possible origin of this large variation in age is discussed.

Thorium minerals from Ceylon give a range from 188 to 506 million years.
A. B. W.

446. *Radio-active Change and the Concept of the Chemical Element.* **F. Soddy.** (Chem. Soc., J. 115. pp. 1–26, Jan., 1919. Chem. News, 118. pp. 85–87, Feb. 21; 97–99, Feb. 28, and pp. 109–112, March 7, 1919. Nature, 102. pp. 356–358, Jan. 2, 1919. Abstract.)—The author gives a valuable and interesting summary dealing in succession with: The transmutational character of radio-active change; distinctions between radio-active and chemical change; ultimate products; radiations; average life; branch series; history of analysis of matter; chemically non-separable elements; radio-active change and periodic law; spectra of isotopes; chemical character of radio-elements; origin of actinium; ekatantalum; atomic weight of isotopes; different varieties of isotopes and heterotopes; nuclear atom. The author duly accentuates the fact that radio-active changes in no way affect or minimise the practical importance of the conception of the chemical element, which continues to have a real significance as representing the limit of the spectroscopic and chemical analysis of matter, which remains, although now known to convey something very different from the prevalent conception of the last century, and one far more difficult to formulate in terms which would be comprehensible to a student still in the elementary stage of chemical knowledge. Atoms of the same chemical element need be no more than chemically alike, and unique chemical and spectroscopic character is the criterion, not of a single kind of atom, but rather of a single type of external atomic shell. Different chemical elements may have the same atomic mass, the same chemical element may have different atomic masses, and the atoms of the same element may be of the same mass and yet be an unresolvable mixture of fundamentally distinct things. Of all the properties of atoms, mass and radio-activity alone depend on the nucleus, the physical and chemical character and the spectrum originating in the outer shell. In consequence of radio-active changes, the chemical elements can no longer be considered the ultimate unchanging constituents of matter; but since the changes are spontaneous and beyond our power to influence or initiate to the slightest degree, the original conception of Boyle, the practical definition of the element as the limit to which the analysis of matter had been pushed, is left essentially almost unchanged.
G. W. de T.

447. *X-rays.* **E. Rutherford.** (Röntgen Soc., J. 14. pp. 75–86, July, 1918. S. P. Thompson Memorial Lecture.)—The first of the annual lectures instituted in memory of the late Prof. S. P. Thompson. After referring to the works of this distinguished investigator, the lecturer proceeded to outline the advances which have been in made X-ray research during recent years. Referring to investigations on the passage of electricity through gases, the work of J. S. Townsend, O. W. Richardson, J. J. Thomson, H. A. Wilson, and Millikan was touched upon and its significance emphasised in connection with the production of X-rays by kathode rays. The importance of the work of J. J.

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Thomson on the nature of negative electrons was shown as the starting-point for the attack on many apparently obscure phenomena and on the problem of the nature of radiation.

In illustrating the similarity between X-rays, kathode rays, and radio-active radiations, the work of Becquerel, the Curies, Rutherford, and Soddy was outlined, and the new conception of isotopic elements considered briefly. C. T. R. Wilson's work on the photography of trails of ions produced by α-, β-, γ-, and X-rays, was mentioned as affording visible proof of the individual identity of the α-particle and the electron.

Apart from the rapid development of our knowledge of the ionisation of gases by X-rays and the pulse theory of the origin of X-rays, no outstanding results of importance on the problem of X-rays were obtained for an interval of more than 10 years. M. v. Laue's proof by diffraction methods that X-rays were a type of light was the first distinct advance. This was immediately followed by the excellent work of W. H. and W. L. Bragg and of Moseley. Bragg's crystal method of X-ray analysis has opened up a tremendous field of research; whilst Moseley's brilliant results, showing the fundamental significance of atomic numbers of the elements, has provided an extremely useful basis for the theoretical consideration of spectra and of the structure of atoms. Moseley's law of "atomic number" undoubtedly fixes the number of possible elements. The theoretical work of Bohr, Sommerfeld, and others has been remarkably successful in explaining, both qualitatively and quantitatively, the doubling of the lines on the hydrogen spectrum and the details of the Stark-effect where a single line in a strong electric field gives rise to a number of satellites. Progress is of good augury that soon an explanation may be obtained of the main points in the complicated spectra of elements and in the detailed structure of the atom.

The production of the Coolidge tube has been a notable service not only to the radiologist but also to workers in pure science, for it provided a controllable source of X-radiation over a wide range of voltage. In this connection the work of Duane, Hull, Webster, de Broglie, and Rutherford is cited. It is shown how the most penetrating X-rays obtainable ($\mu = 8{\cdot}5$, corresponding to 196,000 volts) are still considerably "softer" than the γ-rays from RaC ($\mu = 0{\cdot}5$, corresponding to 1,000,000 to 2,000,000 volts). It is suggested that when crystal methods of analysis fail, it may be possible to investigate the X-ray spectrum in the region of very short waves by studying the corresponding β-ray spectrum. A. B. W.

448. *Atomic Weight of Lead from Samarskite.* **A. L. Davis.** (J. Phys. Chem. 22. pp. 681–689, Dec., 1918.)—The object of this work is an extension of the investigations on the atomic weight of lead of radio-active origin. The author describes his method of determining the atomic weight of lead contained in the mineral samarskite, which mineral is regarded as a complex columbate and tantalate of the rare earths, and contains a considerable amount of uranium with a small percentage of thorium. The results are as follows:—

Atomic weight of ordinary lead	207·354 207·186 207·27
„ „ of radio-active lead	206·246 206·868 206·80

The uranium and thorium contents of the mineral were found to be: U_3O_8, 12·21 %; ThO_2, 1·03 %. A. B. W.

449. *Brightness of Radio-active Luminous Compounds.* **W. C. Clinton.** (Illum. Eng., London, 11. pp. 260–268, Nov., 1918.)—Describes the results of photometric measurements of the brightness of radium luminous compounds of various radium contents and gives curves showing the decrease of luminosity with time. The rate of decay appears to be accelerated by increasing the thickness of the material up to a certain point. [See Abs. 988 (1917).] J. W. T. W.

450. *The Aggregate Recoil of Radio-active Substances emitting α-rays.* **R. W. Lawson.** (Nature, 102. pp. 464–465, Feb. 13, 1919.)—The author outlines certain experiments on the lines of those made by Ratner [Abs. 54 (1919)]. Reference is made to the "wandering" of active matter, as a result of which polonium is found to contaminate electroscopes and ionisation vessels, although the utmost precautions are taken. The author disagrees with Ratner in certain points regarding recoil from polonium, stating that the phenomenon is probably due to the "aggregate recoil" of the radio-active matter. [A paper on aggregate recoil is at present in the press.] A. B. W.

451. *End Products of Thorium.* **J. R. Cotter.** (Nature, 102. p. 425, Jan. 30, 1919.)—Comments on a paper by Soddy on this subject. Cotter disagrees with Soddy in regard to the amount of thallium present in the mineral thorite, stating that he is not even able to detect thallium in the mineral and is confident that less than 0·005 % is present. Soddy, on the other hand [see Abs. 787 (1917)] stated that he has detected thallium in thorite in amounts which sufficed for chemical as well as spectroscopic identification.

F. Soddy. (*Ibid.* p. 444, Feb. 6, 1919.)—In replying to J. R. Cotter, Soddy states that he was able to separate chemically thallium from 20 kg. of thorianite: the quantity separated, whilst being certainly detectable, was less than 0·005 %. Reference is made to Joly's views on the end product of thorium [Abs. 788 (1917)] and to certain observations of Lawson that both the isotopes of thorio-lead appear to be stable. A. B. W.

452. *Emanation Method of Determining Thorium.* **G. H. Cartledge.** (Am. Chem. Soc., J. 41. pp. 42–50, Jan., 1919.)—The well-known emanation method is the best one for estimating small amounts of radium, but thorium cannot be determined similarly because of the short period of its emanation. The author now describes a modified method in which air is continuously circulated through the thorium preparation and through the ionisation chamber, the activity when the system has reached a steady state being noted. The various sources of error are pointed out, with the precautions taken.

A method for preparing radio-chemically complete solutions of monazite sand has been worked out so as to give an accuracy of 1·5 % total ThO_2. A. B. W.

453. *Observations of Ionisation in Closed Vessels at Seeham during the Summers of* 1908 *to* 1915. **E. v. Schweidler.** (Akad. Wiss. Wien, Ber. 126. 2a. pp. 1009–1085, 1917.) [See Abs. 474 (1918) and 1855 (1918)].—Different forms of apparatus were used for these observations. The apparatus can be classified into two groups, according as the test vessels used were airtight or not. The former group gives measures of the penetrating radiation of the surroundings; the latter gives approximate measures of the emanation content of the air.

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Penetrating radiation shows no definite diurnal variation, no clear influence of meteorological changes and very small variability. This radiation is less in a submerged vessel than in one over the sea, where it is again less than in a vessel over land.

The second group of apparatus with non-airtight vessels give considerable fluctuations of strength of ionisation. The diurnal variation is small, there being probably a slight maximum in the night. Meteorological influences produce the following effects:—Reduction of emanation content with and after long-continued rain and with low pressure; increase of emanation content before bad weather, and with north-east wind; the curve of emanation content runs parallel to those of air temperature and absolute humidity, and inversely to that of air-pressure. R. C.

454. *Radio-activity and the Colouration of Minerals.* **E. Newbery** and **H. Lupton**. (Manchester Lit. and Phil. Soc., Proc. 62. 10. pp. 1–16, Oct., 1918.)—Many attempts have been made to explain the source of the beautiful exotic colours in certain minerals, but no explanation so far offered has met with general acceptance. The present work was undertaken, therefore, in order to determine, if possible, how far the presence of radio-active substances must be taken into account when trying to solve the question of the source of these colours.

The minerals chosen for the present experiments were, as far as possible clear crystals of bodies which either were colourless or were known to occur in a colourless state in nature. Exposure to radium was made in most cases by placing a glass tube containing the radium salt directly on or very near to the specimen under observation. In this way only β- and γ-rays actually reached the crystal, and of these only the γ-rays would penetrate to any appreciable depth. In a few cases the specimen was exposed to the direct influence of the emanation by putting it into a tube containing the active gas over mercury. In this case α-, β- and γ-rays would act simultaneously. The results obtained with the different samples are described in detail. There appears to be little doubt that the colours and thermoluminescent properties of many minerals have been largely determined by the presence of radio-active matter either in the water from which they have been deposited or by the subsequent action of radio-active minerals in their immediate neighbourhood. It appears possible, though not proved, that fluorescence is produced by α-radiation as in the case of zircons. Different colours may be produced by β- and γ-radiation and all three effects may be observed in one and the same crystal, *e.g.* the fluorescent purplish green fluor where the green crystal is restored by γ-rays, the purple by β-rays, and the complete colour by placing in a tube of emanation where α-, β- and γ-rays act together. Both β- and γ-radiation appear to be active in producing thermoluminescence. In nearly all cases the colours produced are due to the dissociation of minute traces of certain impurities. The products of dissociation are removed to a very short distance from each other, and the size or density of these particles will determine the particular colours of light absorbed and transmitted. Disturbances of the molecular structure of the crystal by heat, daylight, etc., enables the dissociated particles to approach each other and recombine, with consequent loss of colour. The quantity of impurity may be exceedingly small, since the dissociated body appears to act as a powerful dye, and in many cases it may be impossible to determine its chemical nature largely owing to the difficulty of obtaining a perfectly pure sample of the original substance. The question as to whether a perfectly pure substance is capable of showing these colours is still open to doubt, though Goldstein's work seems to point to the conclusion that such is possible. A. E. G.

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455. *Thermal Conductivity of Air.* **E. O. Hercus** and **T. H. Laby.** (Roy. Soc., Proc. 95. pp. 190–210, Jan., 1919.)—The investigation here described was an attempt to supply an absolute value of the thermal conductivity of air by a method in which the flow of heat by convection was absent. In all past determinations of the thermal conductivity of gases, except those of Todd, the flow of heat by convection was present to an uncertain amount. A guard-ring method was employed, and the special precautions observed are dealt with at length. The mean value for k_0 deduced from the experiments is $5{\cdot}40 \times 10^{-5}$ cal. cm.$^{-1}$ sec.$^{-1}$ deg.$^{-1}$. Combining the results of previous investigators, and giving weight 5 to the above and to Todd's result, the value of k_0 deduced is $5{\cdot}22 \times 10^{-5}$. The relative determinations of the conductivity of gases recently made by Eucken are then used to test the relation $k = fC_v\eta$, where η is the viscosity, and to find the absolute value of f. The results are presented in tabular form. The values of f for He and Ar are respectively 2·31 and 2·47. For six diatomic gases f is about 7/4, and for other polyatomic gases f has a lower value. A. W.

456. *A Convenient Multiple-unit Calorimeter Installation.* **J. D. Davis** and **E. L. Wallace.** (Bureau of Mines, Techn. Paper, 91. [48 pp.] Washington, 1918. Engineering, 107. pp. 33–36, Jan. 10, 1919.)—The paper illustrates and describes the mechanical arrangement that has been found most satisfactory and reliable for carrying out some 90 to 100 calorimetric determinations of coal samples per day at the United States Bureau of Mines. With the methods described it is possible to repeat experiments on duplicate samples with no greater error than 0·1 to 0·2 %. The essential items in the calorimetric outfit are the bomb, the water jacket, the stirrer, and the thermometer. The bomb is of the constant-volume type, made of monel metal and gold plated internally; its water capacity is about 600 cm.^{3}. The sealing device consists of a tough steel receiving nut and lock, so constructed that less than a one-eighth turn with the wrench suffices for sealing. It is an adaptation of the principle employed in the breech locks of cannon. A complete water jacket is employed, since by such an arrangement the effect of variations in room temperature is minimised. Stirring is effected mechanically: a turbine form is best adapted for closed calorimeters, and its rate should be about 500 r.p.m. The increase of temperature due to stirring should not exceed 0·01 deg. C. per min. Six calorimeter units are mounted together and immersed in a well-stirred constant-temperature tank. Thermostatic control is also employed for maintaining a constant temperature in the water used for the calorimeters. A large automatic pipette serves to measure out the quantity required for each determination. The pipette is provided with an overflow pipe and glass stopcocks, and as the water is measured always at the same temperature, one calibration point is all that is needed, and the water is delivered directly into the calorimeter can. The temperature changes of the calorimeter are measured by Pt-resistance thermometers of small lag. These are calibrated to 0·001 deg. C. and a special type of resistance bridge is employed to facilitate the work. A novel feature of the outfit is a distribution switch which permits of the use of one bridge and galvanometer with three

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calorimeters. By means of this switch all the circuits, firing, heating, and thermometer, are shifted across in one movement. It further permits of the use of two thermometers in one calorimeter.

The paper concludes with a careful study of the various possible sources of error in fuel calorimetry. E. G.

457. *Lags of Thermometers in a Medium whose Temperature is changing at a Constant Rate.* **A. R. McLeod.** (Phil. Mag. 37. pp. 134–144, Jan., 1919.)—The lag of a thermometer, situated in a medium whose temperature is changing, is of practical interest in the case of ascending aeroplanes and balloons. The paper contains a mathematical treatment of the problem for the case when the temperature of the medium is changing uniformly. Formulæ are given for the steady values of the lags for spherical and cylindrical bulbs when the surface conductivity is finite, and for the lags at any instant when the surface conductivity is infinite. The lag of the mean temperature of the bulb behind that of the medium is, when steady, of the form $MG\rho\sigma/K$, where G is the constant rate of change of temperature of the medium, ρ the density, σ the specific heat, and K the thermal conductivity of the substance in the thermometer bulb. M is a numerical constant whose value depends on the shape and dimensions of the bulb. Numerical results are given for mercury and alcohol, in spherical and cylindrical bulbs, on a descending aeroplane. The calculated results show that for spherical bulbs of mercury and alcohol giving the same volume expansion the lags are about the same. With the same thermometric substance, the lag is less for cylinders 10 cm. long than for spheres giving the same volume expansion, and it is less for a cylinder of alcohol than for a cylinder of mercury. E. G.

458. *On Evaporation from a Circular Surface of a Liquid.* **H. C. Burger.** (K. Akad. Amsterdam, Proc. 21. 3. pp. 271–276, 1919.)—In literature on evaporation the opinion is frequently expressed or assumed as axiomatic that evaporation from a circular surface is proportional to the area, *i.e.* to the square of the radius of the surface. Stefan, however, showed that theoretically evaporation by diffusion into a quiescent atmosphere would be proportional to the first power of the radius. Miss Thomas and A. Ferguson [Abs. 71 (1918)] found experimentally that the power of the radius which was necessary to produce the observed results was between 1 and 2. In a dark, very quiet room the power was 1·4, in a lighted room it was 1·5 to 1·6; in the open air it was 1·65.

The author, by a mathematical treatment of the diffusion of vapour into a *flowing gas*, finds that evaporation should be proportional to the 5/3rd power of the radius. This agrees with the value found by Thomas and Ferguson for the open air. R. C.

459. *Ignition-Point of Detonating Gas.* **A. Mitscherlich.** (Zeits. Anorg. Chem. 98. pp. 145–166, Nov. 30, 1916.)—An account of experiments, extending over a long series of years, made with electrolytic hydrogen and oxygen while the gas mixture is flowing under reduced pressure through a tube of glass or other material which is sheathed with another tube and heated by gas burners. The ignition is thus spontaneous; the ignition flash is observed through the quartz windows of the tubes or determined by the aid of the mercury pressure-gauge. The noise of the explosion was often imperceptible. There is always a slow combination of the two gases, leading to a gradual contraction, much below the ignition temperature. The rate of gas flow

influences the ignition temperature only when the gas current is very slow; increased pressure raises the ignition temperature (contrary to Dixon and Coward). At a pressure of 150 mm. the flash occurs, in the slowly heated tube, at about 540°. The author first used Jena glass tubes free of arsenic; but he found that owing to the slow combustion below the ignition-point these glass tubes were unsuited for exact determinations except in series of experiments conducted under similar conditions. Other glass did not prove any better from this point of view, and in a tube of 6 mm. diam., made of quartz (crystal), the formation of water was even worse. Light had no direct influence; the results were the same when the tubes were placed inside copper or porcelain sheaths. Previous treatment of the glass with acid or alkali did not prevent the water-formation, which increased strongly with higher temperatures. The final experiments were made with porcelain tubes, especially unglazed, in which there is very little formation of water when they have previously been heated to 700° for a long time. H. B.

460. *Dilution Limits of Inflammability of Gaseous Mixtures.* III. and IV. *Lower and Upper Limits, Mixed Gases and Air.* **H. F. Coward, C. W. Carpenter,** and **W. Payman.** (Chem. Soc., J., Trans. 115. pp. 27–36, Jan., 1919.)—The experiments concern mixtures of hydrogen, methane, carbon monoxide, taking two at a time or all three together, and also a town gas (with 46·6 % H, 19·4 CH_4, 14 CO, further CO_2, C_2H_4, C_2H_6, O, N). A purely additive formula for connecting the lower limits of single gases with the lower limits of their mixtures was given by le Chatelier, but confirmed only by experiments in apparatus of too small dimensions to decide whether the mixtures were capable of continued flame propagation. Experiments with the authors' eudiometer (*ibid.* 105. pp. 1859 and 1865), 30 cm. square, 1·8 m. long of a capacity of 170 litres, show that the formula gives a useful approximation for the mixtures tried and thus also for water-gas and coal-gas. A mixture of 10 % H with 90 % CO behaved somewhat abnormally, however. The formula is $n_1/N_1 + n_2/N_2 + n_3/N_3 \ldots = 1$, where the N values are the lower limits for each combustible gas separately, and the n the proportions of the gas at the dilution limit, each referred to the whole air mixture. As regards the upper limits, the discrepancies between the values of different observers are greater; for hydrogen they range from 55 up to 80 %; for methane from 12 to 17 %. The experiments were made in apparatus of different sizes and as before with sparks from an Apps coil, fed with 2, 4, 8, 12 volts, and with gases saturated with moisture at 18° or 19° C. The formula is again found to hold approximately. The upper limits varied with the nature and size of the vessels (tubes or spheres). They seem to be for hydrogen, methane, carbon monoxide about 74·2, 15·4, 74·2 % respectively. In hydrogen the flame has the form of a pale-blue spherical cap, in carbon monoxide of a bright thimble, the advancing surface being convex; in methane a reddish-brown conical tail ending in a point projects from the cap, and in mixtures of methane and CO the same tail projects from the thimble. The tail is ascribed to secondary reactions. H. B.

461. *Propagation of Flame through Tubes of Small Diameter.* II. **W. Payman** and **R. V. Wheeler.** (Chem. Soc., J., Trans. 115. pp. 36–45, Jan., 1919.)—In collieries safety lamps are tested in mixtures of coal-gas and air, in which the propagation of flames may be faster than in methane-air, probably owing to the presence of hydrogen in coal-gas. The margin of safety is thereby raised; but every additional protective device adopted on the strength of such tests militates against proper ventilation of the lamp and reduces the light-giving power. Further experiments [see Abs. 1171 (1918)] were therefore made on the propagation of flames through tubes in mixtures with air of hydrogen, of hydrogen-methane mixed 1 : 1, and of two kinds of coal gas, differing chiefly as to their percentages of hydrogen and of methane and higher paraffins. The tube diameters ranged from 2 mm. up to 9 mm. The rule of le Chatelier: $n_1/N_1 + n_2/N_2 = 1$ [see preceding Abs.] was again found useful. Expanded, this formula may be written $L = 100(a/L_a + b/L_b + \dots)$ and used to find the limiting percentage L for a mixture of gases from the known limits L_a and L_b of the constituents, a and b being the percentage of the constituent. A similar rule holds also for the speeds of flame propagation; this speed S can be calculated from the corresponding speeds of flames in the mixtures of the individual gases with air: $S = (a + b + \dots)/(a/S_a + b/S_b + \dots)$. The latter formula yields the upper and lower limit mixtures, and the mixtures in which the speed of flame is either lowest or highest. The experiments show the applicability of these formulæ. The range of mixtures over which continued (horizontal) propagation of flame was possible becomes in all cases more and more restricted as the diam. of the tube decreases; in tubes of 3 mm. this range was less than half that in tubes of 9 mm. diameter. In tubes of 2 mm. no flame could travel away from the ignition-point, irrespective of the percentage of combustible gas; this holds for mixtures of air with hydrogen-methane and with coal-gas. With mixtures of methane-air no flame would travel when the diam. was reduced to 3·6 mm.; with 30 % hydrogen and air Mallard and le Chatelier had still observed flame travel in tubes of 0·9 mm. diam. The use of coal-gas for testing safety lamps is objectionable because (1) small variations in the compositions of the gas affect the flame speed considerably, dilution of carburetted gas with water-gas increasing the hydrogen; (2) even with normal retort gas the speed may be more than double the speed in methane-air; (3) the ability of flame to pass through small tubes or holes mainly depends upon the speed, but also on the quality of the gas; flames in hydrogen-air mixtures can pass through very small holes, and the presence of hydrogen in coal-gas imparts this property to a certain degree to coal-gas. H. B.

462. *Inflammation of Ethane-Air Mixtures in a Close Vessel; Turbulence.* **R. V. Wheeler.** (Chem. Soc. J., Trans. 115. pp. 81–94, Jan., 1919.)—The effects of turbulence on the speed with which a flame spreads through gas mixtures has long been overlooked, though, as Dugald Clerk (Brit. Assoc. Committee on Gaseous Explosions, 1912) pointed out, gas engines would have been impracticable if the rates of explosion were the same in engine cylinders as in closed vessels. With normal ignition at the end of the first compression stroke he observed that the max. pressure of the explosion was reached in 0·037 sec.; with ignition at the end of the 3rd stroke, after turbulence had subsided, the interval was 0·092 sec. B. Hopkinson at the same time put a fan in a cylinder, 30·5 cm. diam. and height; max. pressure was obtained, with the fan at rest, in 0·13 sec.; at 2000 r.p.m., in 0·03 sec.; at 4500 r.p.m., in 0·02 sec. The author shows that too great turbulence may extinguish the flame, especially in poor mixtures. The lower limit of inflammability of ethane-air is 3·1 % ethane, but a flame will travel some way in 2·9 %. Running a fan in a sphere of 2·5 litres' capacity, there was no ignition at 100 revs. per sec. in 3·2 %; at 40 revs. per sec. a pressure of 4·5 atmos. was recorded; with the fan at rest, 3·4 atmos. With 3·1 % of ethane, ignition occurred at 40 revs. per sec. only at the 4th spark; at 20 revs. per sec. at once: the pressure was 4·4 atmos. in both cases, after 0·177 and 0·287 sec. respectively. With 8·0 % of ethane no ignition occurred at 100 revs. per sec.; at 20 revs. per sec. ignition was instantaneous, and 4·8 atmos. was recorded after 0·8 sec. Further experiments were made with richer mixtures, also of methane-air, in a sphere of 4 litres' capacity which was provided with a fan, mounted with its shaft vertical in the gland in the lower portion of the apparatus. The flame was seen to be drawn downward, and was sometimes carried round the sphere several times in a spiral whirl. The effect of agitation in enhancing the speed of combustion is mechanical; the flame is not merely propagated by heat conduction from a burning layer to an unburnt layer of the mixture, but is dragged in the wake of the rapid current. When the temperature of the source of ignition is but little above the ignition temperature of a poor mixture, there may be a considerable time-lag [see Abs. 1262 (1918)], so that the flame cannot travel away from the source of ignition at high fan speed. Hence mixtures in which the speed of flame is slow should be particularly susceptible to turbulence. This is further shown by an examination of the curves in which pressures are plotted as ordinates against time. With the fan at rest the curve slopes up gently and then becomes horizontal; as the speed of the fan is raised, the slope becomes steeper and then descends again, there being no horizontal part of max. pressure. H. B.

463. *Formula giving the Heat of Vaporisation of a Liquid.* **E. Ariès.** (Comptes Rendus, 168. pp. 204–207, Jan. 27, 1919.)—This paper is a further contribution to a series of investigations on the equation of state,

$$p = \mathrm{RT}/(v - \alpha) - \mathrm{K}/\mathrm{T}^n(v + \beta)^2,$$

in which the co-volumes α and β are functions of the temperature and represent in a satisfactory manner all the thermal properties of a fluid. It has been shown previously that the constants and functions K, n, α, β may be separately determined by simple methods. In the present paper the author derives from this equation of state a very important formula giving the heat of vaporisation, L, of a liquid, namely:

$$\mathrm{L}/\mathrm{RT} = (y_1 - y_2)\left[\frac{2+n}{8}\mathrm{Z} + \frac{n + 1 + \mathrm{T}\partial/\partial\mathrm{T}\,.\log\Gamma}{\gamma_1\gamma_2}\right],$$

where the symbols are as in preceding papers [see Comptes Rendus, 168. p. 787, 1896]. Like the formula giving the saturated vapour tension of a liquid, the present expression only depends on the exponent n, and on the function Γ; also $\frac{\alpha + \beta}{\alpha_c + \beta_c} = \frac{\gamma}{\gamma_c}$. H. H. Ho.

464. *Critical Phenomena.* **W. R. Fielding.** (Chem. News, 117. pp. 379–383, Dec. 20, 1918.)—About two years ago the author attempted to obtain a general-formula connecting the critical temperature of a gas and its critical pressure. He now publishes his conclusions owing to similar work appearing by E. Ariès, who applies a formula obtained for the argon elements to arrive at the critical data of the monatomic gas mercury. The present paper was originally based on results not yet published, in which the author proved that for inorganic elements and compounds the

C.T. (Crit. Temp.) = (1·714 × B.P. (Boiling Pt.)) + 3·3°.
(All on absolute scale.)

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At comparatively low temperatures the formula is not quite correct, but as the temperature rises it becomes more generally correct. An illustrative table for H, F, N, O, A, Kr, X, NH_3, Cl, H_2O is given. The author next examines the relation between the temperature and pressure at the critical temperature. When critical temperatures are plotted against critical pressures all substances do not lie on one curve; *e.g.* the argon elements appear on a curve which is distinct from that for H, F, Cl, etc. There is an indication of separate curves for each group of elements or similarly constituted compounds. The formula $(C.T. + 236{\cdot}2)/\sqrt{(C.P.)} = 70{\cdot}9$ applies to the elements, and a similar formula $(C.T. - X)/C.P. = k$, where X and k depend on the series to which the substance belongs, applies to inorganic compounds. E. Ariès has calculated the critical data of mercury-vapour from the behaviour of krypton, argon, and xenon, the two first of which, like oxygen and helium, behave in an irregular manner and do not lie on the critical curve. The C.T. and C.P. of compounds are not the sums of the C.T. and the C.P. of their constituents; but in inorganic compounds, as the C.T. rises the C.P. rises, and the value of R falls (in any particular series of similar compounds); whereas in organic compounds as the C.T. rises the C.P. falls, and the value of R rises (in any particular series of similar compounds). In the case of benzene derivatives the value $C.T. \times \sqrt{(C.P.)}$ is highest for the ortho-position and lowest for the para. The value of $C.T. \times \sqrt{(C.P.)}$ is slightly higher for the normal than for the iso-position. As the number of benzene rings in a compound increases, so does the value of $C.T. \times \sqrt{(C.P.)}$. The substitution of one phenyl radical for H in a methane molecule raises the value of $C.T. \times \sqrt{(C.P.)}$; the introduction of a second phenyl radical raises the product of $C.T. \times \sqrt{(C.P.)}$ still further. The introduction of one methyl radical into the benzene ring reduces the value of $C.T. \times \sqrt{(C.P.)}$; a second methyl (in the ortho-position) causes no further change; a third methyl radical probably causes no further change (if the methyl radicals are in the 1-, 2-, 3-positions). In the case of a benzene ring with a side-chain the value of $C.T. \times \sqrt{(C.P.)}$ will probably tend to become constant when the possibility of isomerism has become established.

Ten sets of tables supply most comprehensive data. H. H. Ho.

465. *The First Quantum Theory of Planck.* **A. Smekal.** (Ann. d. Physik, 57. 5. pp. 376–400, Nov. 26, 1918.)—A mathematical paper. An attempt is made to institute a comparison of Planck's two theories, using as experimental basis the susceptibilities of paramagnetic substances. Since a treatment of paramagnetism by means of the second theory has already been given by Reiche [Abs. 798 (1918)], the author deals more particularly with the first theory. It is considered that the calculation goes much more simply by means of the first theory, which, however, carries certain disadvantages.

G. E. A

466. *Criticism on van der Waals' Equation; New Gas Equations, and Cohesion.* **J. Kam.** (Phil. Mag. 37. pp. 65–97, Jan., 1919.)—This paper consists mainly of a re-formulation and elaboration of the arguments of an earlier one [Abs. 345 (1916)] with some further deductions, the most noteworthy of which is the conclusion that the cohesive forces which gives rise to the "Inward Pressure" appear to be identical with the Newtonian gravitational attractions between the molecules. A tabulated series of measurements of the different quantities involved, over a wide range of physical and chemical constitution, appear to justify this conclusion at least to the extent of showing that the gravitational attraction must constitute the principal term in any complete expression of the forces of cohesion. G. W. DE T.

467. *Deduction of the Third Virial Coefficient for Material Points (eventually for Rigid Spheres) which Exert Central Forces on Each Other.* **W. H. Keesom** and [Mrs.] **C. N. van Leeuwen.** (K. Akad. Amsterdam, Proc. 21. 4. pp. 593–601, and pp. 602–606, 1919.)—This paper contains a continuation of the research in which the existing data on the virial coefficients B and C in Onnes' empirical equation of state,

$$pv = A\left\{1 + B/v + C/v^2 + D/v^4 + E/v^6 + F/v^8\right\},$$

were compared with formulæ which can be derived for those virial coefficients starting from different hypotheses on the structure and mutual actions of the molecules. In the preceding papers [see Abs. 907 (1916)] the second virial coefficient B was specially considered. In the present communication the third virial coefficient C is treated, and in section 2 its general expression is derived for material points (eventually rigid spheres) which exert central forces on each other. In section 3, C is calculated for the case that the molecules (rigid spheres) do not attract each other. The value thus obtained is at the same time the first term of a series of ascending powers of T^{-1}, in which C can be developed for the case that the attraction between the molecules varies with the distance according to a law $r^{-(q+1)}$ (potential energy proportional to r^{-q}).

In the second communication the development is given for the next two terms of this series for the laws of force r^{-5} and r^{-6}. These calculations had already been started, when the importance of the theoretical investigation of C was increased by a remark of Holst, who concluded from investigations on compressibility that for substances such as water and ammonia, the molecules of which possess an electric moment such as that of a doublet, C is negative in the considered temperature interval, while for normal substances C is found positive. A calculation of C for molecules whose attraction is equivalent to that of a doublet at their centre and a comparison of this result, *e.g.* with that for molecules like those considered in this communication, or with that for quadruplets, will have to prove whether really the deviating behaviour of C for the substances mentioned must be ascribed to the molecule possessing an electric moment such as that of a doublet. The calculation of C for doublets and quadruplets is postponed to a later paper. H. H. Ho.

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ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

468. *Relativity Theory of Electromagnetic Fields.* **H. Bateman.** (Phys. Rev. 12. pp. 459–481, Dec., 1918.)—Instead of specifying the field by the vectors E and H, as usual, the author obtains a greater generality by using $F = E + 1/c . (v \times H)$ and $Q = H - 1/c . (v \times E)$, where v is the velocity of the observer relative to the field; and shows how various vectors may be located by aid of two cones, which at each point limit the directions of the forces acting on electric and magnetic charges with velocities $< c$. The electromagnetic laws are expressed directly in terms of unit electric and magnetic charges in motion, and it is deduced from one of Hargreaves' theorems for space-time integrals [Camb. Phil. Soc., Tran. 21. p. 137, 1908] that, from the point of view that invariants are symbols for physical entities, independent of the measuring apparatus or method of observation, a moving tube of electric force assumes the form of a definite physical entity. A second Hargreaves theorem suggests that electric quantity may represent a rate of change of another entity—quantity of *proto-electricity* the author calls it. Electromagnetic fields are then considered as derivable from proto-electromagnetic fields containing line charges by a method analogous to differentiation. Field vectors satisfying Maxwell's equations are constructed from the assumption that proto-electric charges (taken as being either positive or negative) travel along straight lines with velocity c, and from a further hypothesis regarding the nature of the vectors. The nature of the energy in an electromagnetic field and of its flow is discussed, and an argument developed suggesting the existence of an immense amount of concealed energy in the field of a moving electron, where it must be borne in mind that the author's theory of the structure of an electric field is based on the view that the electric charge of an electron is being renewed continually by the breaking-up of minute doublets, and that the constancy of the charge is due to a steady state having been attained [Abs. 975 (1918)]. Cases are considered in which an equivalent can be found for the energy apparently lost or transformed when work is done by an electromagnetic field on the electric charges within it. Finally, a type of field is investigated in which a function is found which is essentially positive and an invariant for all relativity transformations. The author calls this quantity *electric storage,* and suggests that a quantity of proto-electricity may be derived from it by a process analogous to differentiation. G. W. DE T.

469. *Energy-flow in Electromagnetic Field surrounding a Perfectly Reflecting Cylinder.* **T. K. Chinmayam.** (Phil. Mag. 37. pp. 9–32, Jan., 1919.)—The general features of the phenomena observable in the immediate neighbourhood of the cylinder have been discussed in a recent paper by N. Basu [Abs. 363 (1918)]. The present author has obtained formulæ for the light intensity throughout the field in the case of grazing incidence, and confirms them experimentally by detailed photometric observations. Taking the origin on the edge of the cylinder, and the normal and tangent in the plane of incidence as the x and y axes,

θ the angular distance of the grazing point from the origin, and ϵ being a small angle which for large values of y approaches $\pi/4$, and a the radius of the cylinder, the maxima and minima of illumination are obtained by eliminating θ from one or other of the pairs of equations $2y\theta + 3a\theta^2/2 = x$, and $2\theta^2(y + a\theta) = m\lambda/2$ or $2y\theta + 3a\theta^2/2 = x$, and $2\theta^2(y + a\theta) = m\lambda/2 - \epsilon\lambda/2\pi$, according as the plane of observation is in front of or behind the edge. The visibility of the fringes is practically constant over the entire plane when this passes through the edge, but decreases when it moves away from the source of light, the decrease being greatest for regions farthest from the surface. For the part of the field between the edge and the source of light, the visibility attains a maximum at the surface. The loci of maxima and minima are given by $r\theta^2 = m\lambda/4$, and the mean lines of flow of energy by $r\theta = \text{constant}$, the actual lines of flow fluctuating about these as is illustrated in diagrams, and a plate shows the variations in visibility of the fringes. When the radius a is very small, the results are practically identical with those obtained in the case of diffraction by a straight edge.

G. W. DE T.

470. *The Ring Electron.* **H. S. Allen.** (Phys. Soc., Proc. 31. pp. 49–64; Disc., 64–68, Feb. 15, 1919. Chem. News, 118. pp. 137–139, March 21, and pp. 149–153, March 28, 1919.)—The author's object in this paper was, while keeping an open mind himself, to present the principal arguments that have been advanced in favour of a model of the electron in the form of an Ampère current circuit capable of producing magnetic effects, with the view of suggesting further lines of investigation. The principal arguments which have been advanced in favour of a ring electron, and were presented by the author with the remark that he did not wish it to be understood that he was in agreement with them all or with the views of all those who have supported this hypothesis, may be summarised as follows:—It is claimed that there is no radiation loss as in the case of a classical electron in orbital motion. It provides the requisite zero resultant magnetic moment for diamagnetic atoms, otherwise difficult to account for. It accounts for the facts of paramagnetism, including the observations of Compton and Trousdale [Abs. 919 (1915)] and of Compton and Rognley [Abs. 566 (1918)], for the asymmetry of certain types of radiation [Abs. 549 (1918)], and for discovery of the effect of the magnetisation of iron upon its absorption for X-rays [Abs. 442 (1916)]. It may account for the small ionisation of gases by X-rays. Grondahl claims to have found evidence for a magnetic electron in certain thermoelectric effects [Abs. 108 (1918)]. The model may be adapted to give Planck's radiation formulæ, and it appears possible that Bohr's theory as to the origin of series spectra may be adapted to the ring electron, retaining the essential points of the quantum theory and Bohr's equations. If radiation is due to pulsations in a ring electron, the Zeeman-effect may be deduced by reasoning on the line of Lorentz's original argument. The scattering of streams of electrons from the sun by electrostatic forces would be to some extent diminished, making it easier to understand the sudden beginning of magnetic storms. Parson has shown that many problems of chemical constitution and stereochemistry may be solved by a magneton theory of atomic structure, and stationary valence electrons become possible. The author believes that all chemical forces are probably of electromagnetic origin, and argues that the Lorentz-Fitzgerald contractions are probably of the same origin, and therefore identical with chemical forces, the explanation of which appears to be facilitated by assuming the existence of ring electrons. G. W. DE T.

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471. *Electric Surface Distribution.* **H. Petrini.** (Ark. för Mat., Astron. och Fysik, Stockholm, 12. No. 8. pp. 1–28, 1917.—This is a purely mathematical investigation of equilibrium distributions of electricity on the surfaces of conductors with respect to the conditions determining the order of the density in the immediate neighbourhood of singular points for which the density either vanishes or becomes infinite. G. W. DE T.

472. *Gradient of Electric Potential in the Air at Kremsmünster from* 1902 *to* 1916. **R. Rankl.** (Akad. Wiss. Wien, Ber. 126. 2*a*. 10. pp. 1863–1887, 1917.) —The chief results are: The seasonal variation of potential gradient for fine days shows a simple period with maximum in Jan. and minimum in June. Diurnal variation when analysed harmonically shows a preponderance of the 24-hourly over the 12-hourly waves, the ratio of the amplitudes being greater than 1 and less than 3 at all seasons. There are 3 maxima during the day, at 10 a.m., 2–3 p.m., and 7 p.m.; the chief minimum occurs at 4 a.m., the other 2 minima are at midday and 5 p.m. An investigation of the data for the 102 finest days shows a satisfactory agreement, both in seasonal and diurnal variation, with the data for the fine days. During the eclipse of the sun on April 17, 1912, potential gradient diminished with increasing phase of eclipse. [See Abs. 1484 (1904).] R. C.

DISCHARGE AND OSCILLATIONS.

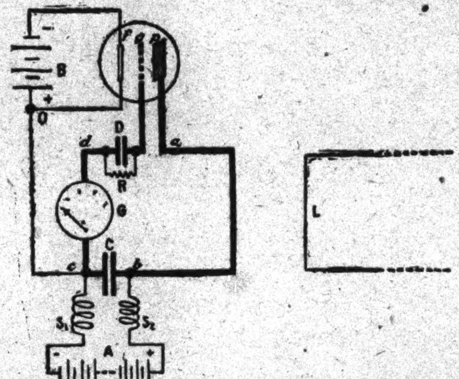
473. *Temperature of Electrodes in the Arc.* **A. Hagenbach** and **K. Langbein.** (Archives des Sciences, 1. (Ser. 5) pp. 48–54, Jan.–Feb., 1919.)—For current intensities not too small, the anodes of metallic arcs (Ag, Cu, Fe, Ni, W) are heated at the tip by the current up to the temperature of ebullition, while the kathodes are heated less. If the end of the electrode is strongly oxidised and forms an oxide with a high temperature of ebullition (Al, Zn, Mg), the temperature rises still higher, probably up to the temperature of ebullition of the metallic oxide. If oxidation is prevented by using an atmosphere of nitrogen, the temperature is lowered to the ebullition temperature of the metal. The temperature of the kathode is found to be the same as that of the anode in the case where metallic oxides are formed. A. W.

474. *Effect of Light on Long Ether Waves.* **O. J. Lodge.** (Nature, 102. p. 464, Feb. 13, 1919.)—The author strongly supports Fleming's recent suggestion that wireless experts should accompany the expeditions for the observation of the coming total solar eclipse of May 29th for the purpose of investigating a curious phenomenon noted by Marconi on the basis of experience in long-distance wireless telegraphy—the impeding effect of the presence of the very short ether waves which ionise air upon the transmission of the long waves originated by alternating electric currents, and may conceivably have something to do with the optical opacity of dry haze. For the benefit of readers other than physicists, he points out that the phenomenon depends on the interaction between free ether and electrified particles immersed in it, and is quite a different effect from optical interference, which is purely ethereal. G. W. DE T.

475. *Fires Originated by Hertzian Waves.* **G. A. Le Roy.** (Comptes Rendus, 168. pp. 224–227, Jan. 27, 1919.)—Several cases of fire have occurred

to which, after a full investigation of the facts, no other origin could be assigned than that of some effect due to Hertzian waves. A laboratory investigation with a considerable number of combustible substances has shown that it is easily possible to start combustion with a very simple apparatus, consisting essentially of a loop of wire 50 cm. or more in diam., provided with a micrometer spark-gap enclosed in a glass chamber provided with four side tubes, two for the electrodes and two for the introduction of various instruments, for exhausting the chamber, if necessary, and for the introduction of different substances. The apparatus thus functions as an ordinary Hertzian resonator. Iron electrodes were found to give the best results. It is suggested that bales of cotton might be set on fire by the action of Hertzian waves if one of the encircling iron bands were accidentally fractured, leaving a small gap between the fractured ends. A. W.

476. *Undamped Electric Oscillations of Short Wave-length.* **Gutton** and **Touly.** (Comptes Rendus, 168. pp. 271–274, Feb. 3, 1919. Rev. Gén. d'Él. 5. pp. 415–416, March 15, 1919.)—Describes the use of a 3-electrode valve for the production of undamped oscillations of wave-length as small as 2 m. The circuit is shown in the diagram. A is a battery of about 300 volts, C a condenser of capacity large relative to that of the anode and grid (0·001 to 0·002 mfd.), and the self-induction of the circuit is simply that of the necessary connections. The introduction of the condenser D (a few ten-thousandths of a mfd.) shunted by a resistance R of 10,000 ohms, makes the arrangement more efficient. With the hot-wire ammeter G in circuit the wave-length can easily be reduced to 3 m., but by substituting for G the filament of a small pocket lamp, still shorter waves may be obtained. Waves of less than 2 m. can be produced by using a valve of very small capacity, and introducing in the oscillatory circuit, between C and G, a condenser of capacity as small as that of the valve. Sustained oscillations can be produced all along parallel wires L, stationary waves being obtained by reflection from the end. Hertz's experiments as regards propagation along wires can thus be easily repeated, with the advantages of undamped instead of damped waves. A. W.



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ELECTRICAL PROPERTIES AND INSTRUMENTS.

477. *Electrical Conductivity of Natural and Synthetic Meteoric Iron.* **C. Benedicks.** (Ark. för Mat., Astron. och Fysik, Stockholm, 12. No. 17. pp. 1–11, 1917.)—The author has measured the resistivity of specimens of meteoric iron with Ni-content varying from 5·3 to 9·9 %. The resistivity increases with the percentage of Ni from 21–29 microhms-cm. For a given Ni-content the resistance is apparently smaller the thicker the layers of kamacite. Two samples containing 6·7 and 11·7 % Ni were produced synthetically by the author and have resistivities of 31·1 and 31·8 microhms-cm. respectively. L. L.

478. *Zero Shift of Moving-coil Galvanometer.* **H. Bäckström.** (Zeits. Instrumentenk. 38. pp. 173–179, Nov., and pp. 189–195, Dec., 1918.)—A discussion of the variation in zero produced in a coil galvanometer by impulses of varying intensities and directions. The effect on the sensitivity of alterations in the form of the coil and of the pole-pieces is investigated. The paper concludes with a very complete bibliography of the subject. J. W. T. W.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

479. *Physiological Tolerance with Intensity of Alternating Currents.* **A. E. Kennelly** and **E. F. W. Alexanderson.** (Soc. Belge Élect., Bull. 32. pp. 92–100, 1915–16–17–18.)—Tesla, Elihu Thompson, and D'Arsonval have already found that high-frequency alternating currents produce only a slight sensation when they pass through the human body, as compared with that produced by low-frequency currents of similar intensity. This insensibility has been attributed by D'Arsonval to the inability of the nerves to respond to excitations of high frequency. In the present paper a special high-frequency alternator is described and the results obtained with it are recorded. The experiments were made by allowing the current to pass through the arms and chest, the hands being immersed up to the wrists in vessels containing a salt solution into which are inserted the electrodes connected with the alternator.

It is found that there is a marked increase in the intensity of the current which can be tolerated when the frequency is increased from 11,000 to 100,000 per sec. A man who can tolerate only about 30 milliamps at 11,000 may tolerate 0·5 amp. at 100,000 per sec. Between 60 and 11,000 periods per sec. there is no very great modification in the current which can be tolerated; it ranges from 5 to about 30 milliamps. As a first approximation, between 11,000 and 100,000 periods per sec. the intensity of the current which can be tolerated increases with the frequency, although it is not certain that the relationship follows a straight-line law. With some subjects it seems to do so, but with others the curve is parabolic and the tolerance increases more rapidly than the frequency. The mean periodic tolerance at 11,000 per sec. is 2·5 microcoulombs per period, and at 100,000 per sec. 5·3 microcoulombs per period. It is difficult to say what the exact law is. The current which can be tolerated is not able to be measured with any great precision. It would seem that, somewhere between 60 and 11,000 periods per sec., there is a frequency at which a max. sensibility to current occurs. A. E. G.

480. *A Biological Basis for Protection against X-rays.* **C. R. C. Lyster** and **S. Russ.** (Röntgen Soc., J. 14. pp. 87–93, July, 1918.)—The harmful effects of X-rays fall into two categories. The direct damage done to tissues by "soft" (easily absorbed) rays is mainly superficial; the indirect consequences may, however, be deep-seated. The harmful effects of "hard" (highly penetrating) X-rays are incompletely known and are at the present day a subject of investigation; with their ever-extending use in X-ray therapy such investigation is of an urgent nature. Such penetrating radiation can, and should, be guarded against no less adequately than the more easily absorbed rays.

In the basis of protection here submitted the amount of radiation reaching the operator in a given time is measured; a comparison is then made between this amount of radiation and an amount which is capable of giving rise to definite biological effects, such as, for instance, the production of erythema or blistering of the skin. Once such a comparison is carried out, a definite statement as to the security of the operator, at any rate as regards the more easily absorbed types of X-rays, may be made. The method adopted is as follows: A quarter-plate is wrapped round with sheet lead 1·5 mm. thick, out of which 4 holes have been punched. The plate with the film outwards is carried in the pocket of the operator during a day's work: the stray X-rays of which he is the recipient will probably be sufficient to produce some impression upon the plate. This plate is now developed in the same dish and for the same time as a plate of the same make which has previously been exposed to a quantity of standard radiation some multiple of which gives rise to a definite biological effect. The standard radiation used is either that emitted from an X-ray tube under definite working conditions or the β- and γ-rays from a known quantity of radium. An accurately timed exposure from either of such sources results in what may be termed a biological basis plate. The biological basis plates have records for six different times of exposure; in the case of X-rays 2, 4, 6, 8, 10, 12 secs., in the case of radium ¼, ½, ¾, 1, 1½, 3 mins. These give a convenient range of tints with which to compare the tint produced by the radiation reaching the plate carried by the operator. The security of the operator is adjudged in the following manner: Suppose that as a result of an average day's work the plate carried in the pocket of the operator gives a tint equal to the 3 minutes' exposure of the radium plate. Then if the more easily absorbed types of X-rays are in question, he is the daily recipient of a quantity of radiation such that ten times this quantity produces a recognisable biological change, and 50 times produces a blister. The same make of plate should be used for the biological basis plate as is used by the operator when he exposes the test plate to the radiation which he may be receiving.

The question of the relative photographic effect of "hard" and "soft" X-rays is also considered. A. E. G.

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CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

481. *Ultimate Structure* (Feinbau) *of Crystals.* **F. Rinne.** (Neu. Jahrb. Mineral. II. 2. pp. 47–105, Nov. 7, 1916.)—The studies of stereochemistry, stereophysics, and of the structure of crystals and amorphous substances by X-rays enable us to inquire into the *Feinbaulehre* (leptonology) of matter. The influence of the electrons will have to be taken into account, and the researches on liquid crystals will be of service also in the consideration of the mechanics of the transition from the crystalline to the amorphous state. In his outline of a theory the author discusses the continuous series of the forms of matter, gases (hydrogen, after Stark and Debye), liquids, liquid crystals, and crystals with the aid of a large number of X-ray diagrams after Laue, Bragg, Debye, and Scherrer, and with special regard to isomorphism, polymorphism, and morphotropy. A crystal may consist of uniformly and periodically grouped atoms; sometimes periodical agglomerations separate from the mass, and finally the whole crystalline mass may be subdivided into crystallographical atomic complexes chemically of the nature of molecules. The growth of crystals is due to the peculiarities of the surface valencies in the sense of Haber and Paneth. H. B.

482. *Chemical Reactions at Low Pressures.* II. *Cleaning-up of Nitrogen by a Heated Molybdenum Filament.* **I. Langmuir.** (Am. Chem. Soc., J. 41. pp. 167–194, Feb., 1919.)—As in previous experiments with tungsten filaments [see Abs. 984 (1915)], molybdenum filaments were heated to temperatures ranging from 2000° to 2400° abs. in nitrogen at pressures of 40 bars (0·03 mm. Hg) or less, great care being taken to exclude water-vapour. Since the filaments lost weight at the same rate as if heated in a vacuum, the nitrogen evidently did not attack the filaments. Moreover, the gas disappeared at a rate independent of the pressure at all pressures above one bar approximately, and the amount of nitrogen cleaned-up was much less than the chemical equivalent of the Mo evaporated. If ϵ denotes the ratio of the number of molecules of nitrogen cleaned-up to the number of atoms of Mo evaporated at the same time, the results show that ϵ decreases as the filament temperature or bulb temperature is raised. The highest value of ϵ obtained was about 0·4, the lowest being 0·01. With very minute pressures of water-vapour such as result, even in the presence of drying agents, from failure to bake out the bulb, no clean-up of nitrogen occurs. Under these same conditions, however, molybdenum will clean up CO, and tungsten will clean-up nitrogen or CO, ϵ in each case being unity. Since ϵ is independent of the pressure, but varies with the bulb temperature and filament temperature in the case of Mo, it is concluded that the reaction takes place in the space round the filament, and that each collision between Mo atoms and nitrogen molecules results in combination, at least two products being formed. These products are probably a first-order compound of the formula NMoN, and a second-order compound $Mo : N_2$. The proportion of these two compounds depends on the relative velocity of the molecules at the moment of collision and also on the internal energy of the nitrogen molecules. The first compound is very stable and cannot be decomposed on the bulb by heating to 360°; its formation is favoured by low relative translational velocity of the colliding molecules and by high internal or rotational velocity in the nitrogen molecule.

All these collisions which do not yield the first-order compound give the compound of the second order, which is so unstable that it decomposes practically completely on striking the bulb. This instability is due to the much greater attractive forces between pairs of Mo atoms than between these and nitrogen molecules.

The deposit which collects on the bulb has the following properties :—(1) It is spongy and can easily be rubbed off by the finger on opening the bulb, whereas deposits formed in a high vacuum are dense and can be hardly scratched off with a knife. (2) If it is formed with the bulb at liquid-air temperature it gives up some of its nitrogen on being warmed to room temperature, but only a part of this nitrogen is absorbed again on cooling the bulb. The larger part of the nitrogen in the deposit is not liberated by heating in a vacuum at 360°. (3) It readily and quickly absorbs up to about 1/30 of its chemical equivalent of nitrogen when cooled by liquid air, but does not readily absorb hydrogen under these conditions. (4) At room temperatures and above, it slowly absorbs or dissolves large quantities of hydrogen, which it slowly gives up again at 300° in a good vacuum. (5) When heated in nitrogen to 270° or higher it combines with that gas, which is not given off again by heating in a vacuum to 360°. (6) It reacts rapidly with water-vapour at room temperature, producing hydrogen, much of which remains dissolved in the deposit until liberated by heating. T. S. P.

483. *Germ Method for Preparing Colloidal Metals of Definite Properties.* **R. Zsigmondy, C. Hiege,** and **J. Reitstötter.** (Zeits. Anorg. Chem. 99. pp. 105–117, May 22, 1917.)—In order to prepare colloidal gold solutions having uniform size of particles, reduction of gold chloride dissolved in distilled water may be effected by means of formaldehyde ; the method gives a pure ruby-red colloid, but is very sensitive to the presence in water of impurities which cannot analytically be detected. Hence the use of germs is recommended again. The germs or nuclei are prepared by adding phosphorus to slightly alkaline gold solutions. The spontaneous formation of more nuclei is suppressed by the addition of ammonia or of yellow or red prussiate of potassium, whilst alkali halide, hydrogen sulphide, or colloidal sulphur prevents the growth of the germs. The remedies of either class do not interfere with the other effect. When the spontaneous formation of germs is suppressed by reagents, the number of submicrons formed is proportional to the volume of the germ solution, for germ particles of 3·5 $\mu\mu$. The spontaneous formation of germs can further be prevented by working with gold concentrations, such that the supply of gold is exhausted before an appreciable spontaneous formation has set in. Red solutions are obtained with the aid of hydroxylamine hydrochloride, which may be rendered alkaline by potassium carbonate ; in more alkaline solutions the solutions are blue. The addition of gold germs to solutions of silver and mercury salts, in themselves stable, though containing reducing agents, leads to the formation of colloidal solutions. Pure water is obtained by distilling permanganate solutions with the aid of a gold condenser. H. B.

484. *Molecular Properties of Glass at Higher Temperatures.* **H. Schulz.** (Deutsch. Phys. Gesell., Verh. 20. pp. 240–249, Dec. 30, 1918.)—The theoretical treatment of the cooling problem of solids is rendered difficult by our very scanty knowledge of the thermal constants at high temperatures. Glass, moreover, must be regarded as a solution of extremely low molecular mobility rather than as a solid. Chemical changes probably take place,

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especially during the softening of the complex substance which has no definite melting-point. It is hence customary to limit theoretical considerations concerning glass to certain temperature ranges which are fixed by the mechanical properties. Zschimmer proposed for this purpose the "cohesion temperature," at which the adhesion becomes equal to the cohesion and two pieces of the glass adhere to one another. The author, of the C. P. Goerz Optical Works, proposed [Abs. 1989 (1918)] to determine the strain set up by rapid cooling and incidentally the softening temperature. Although all the constants of glass are influenced by strain, the results of the two methods are in fair agreement, for lead glasses softening between 400° and 500°, *e.g.* generally within a few deg. C., probably because both the methods are really based upon the determinations of the molecular mobility. In the author's formula for the distribution of strains both the deformation and the relaxation-period are treated as temperature functions. The period of relaxation varies inversely as the energy content of the body (Einstein), and can be determined from the absorption. A glass will, *e.g.*, show absorption at 20μ and $0{\cdot}2\mu$; only the former kind need be considered, because (Rubens) the absorption in the infra-red shifts in the direction of greater wave-lengths when the absorption in the ultra-violet is displaced in that direction. For two glasses of similar composition the period of relaxation will hence be the shorter (and the plasticity the greater), the more the absorption of high-frequency radiation approaches the visible spectrum. The absorption may for approximate estimates be determined at relatively low temperatures.

H. B.

485. *Movement of Atoms in Bismuth during Crystal-gliding.* **A. Johnsen.** (Centralblatt. Mineralogie, pp. 385–392, Aug. 15, 1916.)—From his general studies on the movements of atoms when gliding under shear stress and the results of the X-ray studies of W. H. and W. L. Bragg the author concludes that there are two sets of gliding planes in the rhombohedral crystals of Bi, and that the molecules are diatomic and possess the same degree of symmetry as the whole crystal; the distance between the atomic centres is 8×10^{-8} cm. The diatomic character is also shown by solutions of Bi in large masses of lead, and by the vapour density of bismuth which between 1600° and 1700° is intermediate between Bi and Bi_2. Larger molecules than Bi_2 do not appear to have been observed.

H. B.

486. *High-temperature Researches.* X. *Aluminium and Carbon.* **O. Ruff** and **E. Jellinek.** (Zeits. Anorg. Chem. 97. pp. 312–336, Oct. 12, 1916.)—The preparation of aluminium carbide by heating the elements in a carbon crucible in an atmosphere of hydrogen is exceedingly difficult and only possible with pure materials and in the absence of nitrogen which decomposes the carbide formed, Al_4C_3, into graphite and the nitride AlN; the aluminium carbide is hence an excellent absorbent for nitrogen. The product obtained in half an hour at 2000° was a compact substance of dark orange colour, which contained some Al or some carbide richer in Al. Treated with hydrochloric acid the carbide yields methane, but some hydrogen was liberated as well, from 2·5 to 19 %. A little above 2200° the carbide melts, partly decomposing into Al and graphite. The vapour evaporated from the carbide at 2270° and at 1 atmo. contained 18·3 to 14 % of carbon, corresponding to 55 % Al_4C_3, supposing no other carbide to be present. At high temperatures and pressures the carbon percentage in the

vapour increases. Vapour of aluminium carbide is yet more stable than the vapours of the carbides of metals of the iron group: Fe, Ni, Co, Mn.
H. B.

487. *The Formation of Diamond.* **C. A. Parsons.** (Inst. of Metals, J. 20. pp. 5–24, 1918. May Lecture. Engineering, 105. pp. 485–487, May 3, 1918.)—A brief illustrated account of the author's experimental researches since 1886, resumed in 1907 with a more powerful hydraulic press of 2000 tons and a storage battery of 360 kw., giving currents up to 48 volts and 80,000 amps.; the press was placed in a strong house (walls 2 ft. thick), partly underground. In these apparatus more than 200 reactions, sometimes accompanied by violent explosions, with carbon and carbon compounds were studied at pressures of 4400 atmos. and high temperatures (also in CO_2 snow); generally a soft coating of amorphous carbon was produced on the central heating rod; any traces of diamonds found (analysed after Moissan and Crookes) seemed to be associated with iron intentionally introduced or fused from the pole-pieces, etc. In the furnace experiments on melting carbon in bulk the author—like Threlfall independently—found that graphite heated as a core or cored about a rod of iron or tungsten remained graphite, or was vaporised and recondensed, when heated at 15,000 atmos. pressure; it did not turn into an insulator. A light piston of tool steel was then driven, by the powder charge, from a rifle into the bore of a steel block, fitting like a cap over the end of the barrel; the travel of the piston was 36 in., the bore was charged with oxygen and an excess of acetylene (to liberate carbon); the mixture would explode, the gas compression being 288 to 1; the pressure reached 15,000 atmos., the temperature possibly 17,700° C.; the steel surfaces were fused and turned glass-hard, but the resulting brown amorphous carbon powder contained no diamonds. In further experiments a cordite charge was used to drive a cylindrical bullet from a stronger rifle into a cavity in a block of steel or tungsten steel, the cavity charged with graphite, sugar carbon, oils, etc., sometimes mixed with nitrates or fulminates. The cavity was afterwards found to be enlarged, or the block cracked, and the bullet deformed; but only in two cases was a reasonable amount of diamond residue obtained, and in these cases some iron had been fused. Bullets were also shot through incandescent carbon rods or arcs bridging a small gap. The investigation of the combustion which solidifying cast iron undergoes proves that this contraction is only moderate and cannot exceed 1000 atmos.

The important fact revealed by the author is that the pressure of the occluded gases in the metal, not the bulk pressure on the iron, is the real cause of the production of diamond. Iron was fused in a carbon crucible, transferred to a steel die and subjected to 11,200 atmos., a pressure many times greater than the contraction pressure. When the iron was allowed to set before applying the pressure, the amount of diamond found was much greater than when compressed while still molten, probably because the occluded gases can escape through the molten metal, but not through the crust of set iron. Experiments by merely applying bulk pressures to iron were resultless, and quick cooling of molten iron in CO_2 snow or water at 6000 atmos. gave very little diamond; thus quick cooling as such is not a factor in diamond formation. Another promising line of experiments meriting further investigation consisted in oxidising iron alloys, fused in the electric furnace, with the aid of superheated steam; there was a diamond residue amounting to 5% of the oxides formed. The presence of diamonds in some meteorites suggested vacuum experiments. Some meteoric matter,

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fused by collision, may have been ejected into space and cooled by radiation, and as the occluded gases would be unable to escape, carbon may have crystallised. By the aid of a molecular air-pump X-ray vacua were produced in an electric furnace in which a crucible was heated. Iron and its alloys gave off their occluded gases so briskly that the metal was ejected from the crucible, and in such cases diamonds were found in the ejected mass, not in the crucible contents. Under ordinary conditions both the liberation and the occlusion of gases by iron and its alloys take place slowly. When making the experiment in a container charged with CO (at 1 in. of mercury) prolonged heating followed by cooling yielded a diamond 0·7 mm. in length.

In the carbon-melting experiments at 15,000 atmos. the momentary pressure probably rose to 300,000 atmos., which is about half the assumed pressure at the centre of the earth, but only a very small fraction of the pressure probable in stars or produced by cosmic collisions. One source of diamond might therefore be attributed to the fall of meteorites; such conditions would not be reproducible. The consideration of the pressure of the occluded-gas suggests other possibilities. An ingot or spherule of molten iron surrounds itself on cooling with a thin coating of solidified metal which below 600° C. becomes impervious to gases. As the crust thickens, the gas ejected by the solidifying metal is forced inward, and the gas pressure may burst the crust, which would account for the shredded appearance of some alloys (occluding more gas than iron does). Now Crookes observed by the polariscope in hundreds of diamonds evidence of high internal strain and also a slight flaw or a cavity filled with gas at enormous pressure. As a (natural) diamond is rapidly corroded by contact with molten iron, the author thinks that the formation of diamond in iron must take place at about 690° C., one of the recalescence points, while the iron is still somewhat permeable to gas. With respect to the reactions, iron, carborundum, sulphur, and CO seem alone to be concerned, but the carbides of other metals may also take part; the gases given off by iron contain silicon, and the formation of iron carbonyl from iron and CO is favoured by high pressure.

It is noteworthy that the yield of diamond is always extremely small, so that small quantities of the reagent would suffice; the blue ground of Kimberley contains about 1/5,400,000 of its mass of diamond, whilst experiments with cooled iron have given 270 times that yield. If large masses of alloys could be heated and treated with CO at a pressure of 1000 atmos. after setting, but at a temperature when the metal is still permeable to gas, diamonds might be obtained in paying quantity and size.

It is further noteworthy that diamonds generally occur associated with crystals of silica, alumina, magnesia, spinel, etc., which are associated also with diamond in rapidly cooled iron. According to Bonney, diamond has been traced to an igneous rock; the blue ground is not the birthplace of the diamond, nor of the garnets, pyroxenes, etc., accompanying it, but the diamond is a constituent of eclogite, just as zircon may be a constituent of granite or syenite; the regular form of the diamond suggests that it was the first to crystallise in the magma. According to the author, suitable temperature and pressure might also cause CO to crystallise in olivine, blue ground, or eclogite, in the presence of carbides or carbonyls; on that supposition no molten iron matrix would be required, and the diamonds would be formed in the blue ground itself at an earlier stage, deep down in the earth. H. B.

488. *Cerium-Iron Alloys.* **R. Vogel.** (Zeits. Anorg. Chem. 99. pp. 25–49, March 15, 1917.)—The experiments were made with a cerium of 95·6 %

containing lanthanum and traces of iron, but apparently no praseodymium or neodymium; further, with ferro-cerium from the Elektrochemische Werke, Bitterfeld, with from 15 to 75 % of iron. High-grade alloys are prepared by melting cerium and adding iron, or by dipping pieces of cerium attached to iron wires into the iron; to prevent oxidation the operations are carried out in a nitrogen atmosphere, but when the cerium came in contact with the hot Haldenwanger porcelain it caught fire and burnt to oxide or nitride. The fused cerium began to crystallise at 775°. Cerium and iron are miscible in all proportions and form first $CeFe_2$ which at 773° passes into Ce_2Fe_3; the latter decomposes at 1085° into a liquid and a solid solution richer in Fe. The CeF_2 is magnetic, but loses its magnetism at 116°; for alloys with 25 % of Ce there is another transformation point at 795° which is lowered in richer Ce alloys, until it finally drops suddenly to 116°. The pyrophoric character of the alloys is not merely a question of oxidation and friction; Ce itself is much more oxidisable than CeMg, but less pyrophoric than this alloy. The pyrophoric character seems to depend upon two factors: (1) the presence of at least one Ce compounds in the form of hard brittle crystallites which does not oxidise at ordinary temperature; this holds for alloys with Sn, Al, Si, Bi, Sb, Cu, Pb known in definite compounds; (2) the presence of a softer, more oxidisable material, which in the case of MgCe is cerium itself. This applies also to ferro-cerium which, with 50 or 60 % Ce, is not a good igniter, but becomes so by the further addition of cerium. When the crystallites are firmly interwoven, rubbing or filing does not expose fresh surfaces of oxidisable material; to produce ignition the softer material has to be exposed. H. B.

489. *Action of Oxygen on Ruthenium.* **A. Gutbier, G. A. Leuchs, H. Wiessmann,** and **O. Maisch.** (Zeits. Anorg. Chem. 96. pp. 182–206, Aug. 1, 1916.)—A continuation of the work of Gutbier and F. Ransohoff (1905). The metallic ruthenium was obtained by reducing the tetroxide with alcohol, and the dioxide formed with hydrogen. When the powdered metal is heated in oxygen, the absorption of oxygen corresponds to RuO_2, but there is always a deficiency of at least 0·2 %, because some metal volatilises as tetroxide so that the termination of the reaction cannot be fixed. This volatilisation occurs at all higher temperatures, but is 4000 times as great at 1200° as at 700°. The rate of oxidation is also much more rapid at higher temperature. The decomposed tetroxide is deposited as a bluish dioxide on spots where the temperature is 500°, and as amorphous substance. The metal itself becomes more compact by being heated to 800°, loses its fine lamellar structure, and is then less oxidisable. H. B.

490. *Pure Bismuth.* **F. Mylius** and **E. Groschuff.** (Zeits. Anorg. Chem. 96. pp. 237–264, Aug. 1, 1916.)—Bismuth generally contains as impurity many metals and non-metals, though the total impurity may amount to less than 1 %. The authors (at the Reichsanstalt) prepared their metal for the study of the allotropic transformations from the nitrate, which is heated, and the oxide reduced with the aid of potassium cyanide. The metal can finally be melted under paraffin for the last purification; but the purification of the nitrate by crystallisation is the most satisfactory method and preferable to electrolytic purification. In Kahlbaum's best bismuth they found less than 0·01 % of impurity, copper 0·001 % being alone determinable, with traces of lead and iron. The melting-point of the pure metal is 271·0°; various observers had found 262° to 277°, and the statements

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as to freezing-point depressions were discordant. The resistivity decreases as the purity is raised; the value found is 1·19 or 1·20. T. Schuchardt has observed 1·3 and in one case 3·1, but the latter bismuth was impure with tin. Yet the authors' resistance of bismuth, pressed into wire at 195°, 1·2, is higher than Lenard's 1890 value of 1·09 to 1·16. H. B.

491. *Structure of Iron-Carbon-Chromium Alloys.* **T. Murakami.** (Tôhoku Univ., Sci. Reports, 7. pp. 217–276, Dec., 1918.)—An account of an investigation of 115 alloys, with 56 micrographs and 68 figures. The following carbide of chromium and double carbides of iron and chromium are believed to occur in normal steels: Cr_4C, $Fe_3C . Cr_4C$, $(Fe_3C)_9 . Cr_4C$, and $(Fe_3C)_{18} . Cr_4C$. On heating the steel to the A*c*1 point the double carbides dissociate and thereafter Cr_4C gradually decomposes to form Cr_3C_2 and metallic Cr, according to $2Cr_4C = Cr_3C_2 + 5Cr$. It is only at very high temperatures that this change is at all complete. The recombination of the Cr_3C_2 and Cr is slow, with the result that if the steel is reheated to about 1200° C. and then cooled, the A*r*1 point, which occurs in the normal steels in the region of 700° C., is considerably depressed. Chromium up to 20 % produces very little change in the temperature of the magnetic critical point A2, but higher proportions lower this temperature profoundly, as shown below:—

Cr, %.	0	10	20	30	40	50	60	70	75	80	85	90
Temperature of A2	790	785	760	670	590	480	350	170	80	0	− 100	< − 180

Of the double carbides only the one richest in Fe_3C is magnetic, with a critical point at 150° C., the other two being non-magnetic. For the microscopic detection of the double carbides use has been made of an etching reagent consisting of 10 gm. potassium ferricyanide and 10 gm. potassium hydroxide in 100 cm.^{3} of water. The effect of this agent on the various carbides is described. Iron and chromium form an uninterrupted series of solid solutions with a minimum in the freezing-point curve at 70 % Cr. Chromium will dissolve Cr_4C, corresponding to 0·6 % carbon in the solid state. Cr_4C and chromium form a eutectiferous series with a eutectic corresponding to 1·7 % carbon. The influences of Cr on the microstructure of the normal steels include a lowering of the eutectoid composition, *i.e.* the carbon content at which free ferrite disappears, the structure becoming entirely pearlitic. With 10 % Cr the carbon content has been lowered from 0·9 % to 0·45 %, and with 20 % Cr to 0·28 %, a finer structure resulting both as regards the areas of ferrite and pearlite and also as regards the structure of the pearlite itself, while in addition the pearlite areas occupy a larger proportion of the field than in a plain carbon steel of the same carbon content. F. C. T.

492. *Rapid Recrystallisation in Deformed Non-ferrous Metals.* **D. Hanson.** (Inst. of Metals, J. 20. pp. 141–145; Disc. and Corres., 146–166, 1918. Engineering, 106. pp. 403–404, Oct. 11, 1918.)—Some results are given of the examination of recrystallisation of Al, Mg, Zn, Pb, Cu, Cu-Zn-Al alloy and 70:30 brass after deformation and reheating. The method adopted was that used by Chappell in a similar research carried out on iron [Abs. 607 (1915)]. This consists in cutting a test piece, tapered towards the centre and which, after it has been annealed, is broken in tension. In this way varying degrees of deformation are obtained ranging from a maximum at the point of

fracture to zero at a position between the fracture and the shoulder. In the case of Al, coarse crystals developed in the neighbourhood of the shoulder where the strain was least; after annealing at 480° for $\frac{1}{2}$ hour, in the shoulder itself the original fine structure was obtained. From the large crystals near the shoulder towards the fracture the size of the crystals gradually decreased. Similar results are noted on examination of the other metals mentioned, and these results indicate that for every degree of deformation there is a critical recrystallisation temperature at which crystal growth is extremely rapid: and the size of the crystals produced by this rapid growth is the greater, the smaller the amount of deformation preceding such annealing. The rate of increase in size of the newly-formed crystals with prolonged time and increased temperature of annealing is small compared with their rate of growth at the critical temperature. C. O. B.

493. *Effect of Progressive Cold Work on Copper.* **W. E. Alkins.** (Inst. of Metals, J. 20. pp. 33–46; Disc. and Corres., 47–60, 1918. Engineering, 106. pp. 283–285, Sept. 13, 1918.)—Assuming that the tensile strength of a hard-rolled wire is the sum of two factors, one depending on the cross-sectional area, *i.e.* the normal tenacity, and the other on the circumference, *i.e.* the skin-effect due to the drawing, the max. stress for a wire of radius r should be $r + c/r$, where c is a constant. This result does not agree with the values determined experimentally. By plotting the tenacity of hard-drawn copper wire against the corresponding cross-sectional area as the wire is drawn progressively finer a curve is obtained which consists of three branches. The branch corresponding to the smallest reductions is a straight line whose equation is $T = 31{\cdot}6 - 67A$, where T is the tensile strength in tons per sq. in. and A the area of the wire in sq. inches. This is joined by a curved portion where $T = 28{\cdot}2 - \sqrt[3]{(A - 0{\cdot}107)}$ to another straight line $T = 30{\cdot}83 - 32{\cdot}66A$. The constancy of property with continued cold-drawing at a certain point is also found in the specific volume, elongation, and scleroscope hardness. It is suggested that the results are due to an allotropic change, the two straight lines corresponding to the effect of cold work on the α and β modifications respectively. F. C. T.

494. *Physical Chemistry and its Bearing on the Chemical and Allied Industries.* **J. C. Philip.** (Soc. Arts, J. 67. pp. 94–102, Jan. 3; 108–118, Jan. 10, and pp. 122–131, Jan. 17, 1919. Cantor Lectures.)—The author discusses equilibria and reaction velocities and shows the industrial importance of the accurate quantitative investigation of chemical reactions by physico-chemical methods. Catalysis is also dealt with and the adsorption of dissolved substances by finely-divided solids. Applications of the results of physico-chemical investigations to the production of sulphuric acid, the synthesis of ammonia, the water-gas equilibrium, hydrogenative effects, dyeing and agriculture, etc., are described. A. F.

495. *Actual State of Theory of Electrolytic Dissociations in Water and other Solvents.* **B. de Szyszkowski.** (K. Vetensk. Akad. Nobel Inst., Meddel. 3. No. 11. pp. 1–16, 1916.)—The author ascribes the deviation from the law of mass-action in the dilution formula to the influence of the undissociated molecules in his formula: $\alpha^2C/(1-\alpha) = K + k(C_0^{\frac{1}{3}})^m$, where α is the degree of dissociation, C the concentration, $C_0^{\frac{1}{3}}$ the linear concentration of the undissociated molecules, K the constant of mass-action, k a coefficient expressing the activity of the neutral molecules, and m a power exponent ranging in

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value from 1 to 8; $C_s = C(1-\alpha)$. Without reference to any particular formula the author discusses the figures of various experimenters, chiefly of Kraus and Bray on non-aqueous solvents, who consider the influence of the ionised molecules as decisive. The constant *m* varies, in the solution of minimum conductivity, inversely as the distance between the molecules in the electrolyte, and the concentration of that particular solution is the greater, the greater the specific inductive capacity of the solvent. H. B.

496. *Electrochemical Behaviour of Metals.* **A. Smits.** (K. Akad. Amsterdam, Proc. 21. 1 and 2. pp. 158–171, 1918.)—Every metal probably contains metal atoms, metal ions (of one or more kinds and valency ν), and electrons. Immersed in an electrolyte, the heterogeneous equilibrium (Nernst) between the metal and the boundary liquid will be established with great velocity; the velocity with which a metal assumes internal equilibrium under definite conditions is one of the most characteristic properties of metals. The heterogeneous equilibria almost at once established in an electrolyte will be: $M_S \rightleftarrows M_L$, $M\nu \rightleftarrows M_L\nu$ $\nu\theta_S \rightleftarrows \nu\theta_L$. Whether there will also be homogeneous equilibrium in the co-existing phases will depend on circumstances; the establishment of internal equilibrium may, at ordinary temperature, be rapid or very slow for a metal in contact with an electrolyte. In an acid the two equilibria will be $H_{2L} \rightleftarrows 2H_L^{\cdot} + 2\theta_L$, and $M_L \rightleftarrows M_L^{\cdot} + \theta_L$, and the electron-concentrations of these two equilibra will in general be different. As a consequence, either the electrons of the metal equilibrium in the liquid combine with the hydrogen ions of the hydrogen equilibrium, which causes electrons plus ions (from the metal) to go into solution, or the electrons of hydrogen equilibrium together with the metal ions of the metal equilibrium pass from the electrolyte into the metal. These conditions are discussed with respect to the p.d. between metal and electrolyte when the metal: (1) is attacked (zinc investigated by Hüffer); (2) is inert (nickel), the inertia increasing under the influence of the dissolved hydrogen (passivated metals); and (3) is unattackable and ideally inert and passive in most electrolytes (platinum). The phenomena are further considered in the light of the phase-theory. Potential determinations were made by the author and Lobry de Bruin with nickel electrodes heated in a vacuum or placed in a solution through which hydrogen was passed. In the latter case Pt shows almost immediately the hydrogen potential, whilst Ni assumes this potential after some hours. The equilibrium potential of Pt in aqueous solutions cannot be determined, because the potential is almost exclusively determined by the electron-concentration of the electrolyte, but this determination is still possible for nickel. H. B.

497. *Galvanic Ennobling of Metals.* **C. M. van Deventer.** (Zeits. Phys. Chem. 91. pp. 687–700, Oct. 10, 1916.)—Together with H. J. van Lummel the author had shown in 1909 and 1910 that a metal like Mg, when galvanically coupled with a more noble metal like Zn, may yet be rendered the positive pole by immersing the Mg in a layer of a mixture of alcohol and water and the Zn in aqueous sulphuric acid. Self-ennobling may be effected by immersing different portions of the same metal into the two liquids. The author had ascribed the effect to the fact that the aqueous alcohol is a poor electrolytic conductor. But he finds that the effect takes place also when the alcohol mixture has taken up enough sulphuric acid to conduct fairly well, and that there is no ennobling if too much water (above 10 volumes or less) be present. Accurate e.m.f. measurement made with couples of Mg, Zn, Cd, Sn in various combinations, sometimes of two electrodes of the same metal, gave, *e.g.*, Zn_+/Zn_-, 280 millivolts; Zn_+/Mg_-, 1250; Cd_+/Mg_-, 1200 millivolts. The cause of the ennobling is the formation of a film of sulphate or other salt, insoluble in the alcohol-water mixture and electrolytically a bad conductor. Lead can be much ennobled in this way. Non-amalgamated Al is noble compared to zinc, amalgamated Al is not. H. B.

498. *An Electron Theory of Passivity.* **R. S. Dean.** (Am. J. Sci. 47. pp. 123–125, Feb., 1919.)—To make an electron theory of passivity probable three things must be accounted for, namely: (1) the maintenance of an electron-deficient electrode surface; (2) the characteristic occurrence of passivity in metals of the iron group; (3) the effect of magnetism on passivity. The author analyses mathematically the conditions affecting the surface concentration of electrons, and shows that the electron density at the surface is less than that of the interior and that the more paramagnetic the substance the greater the passivity. It is further shown that if a magnetic field be applied to a conductor the passivity produced will be less in the magnetic field than without; the passivity once having been produced, however, any change of the magnetic field should have no effect. The theoretical deductions thus agree with the experimental behaviour observed by Nichols and Franklin (*Ibid.* 34. p. 419, 1887) and by Byers and Darrin [Abs. 1375 (1910)]. L. H. W.

499. *The Passivity of Chromium.* III. **A. H. W. Aten.** (K. Akad. Amsterdam, Proc. 21. 1 and 2. pp. 138–150, 1918.)—Explanatory considerations of the phenomena previously described [see Abs. 814 and 882 (1918)]. The activity of the Cr is due to the hydrogen in its surface layer. Chromium containing little hydrogen does not spontaneously dissolve in diluted sulphuric acid. Kathodically polarised it dissolves under generation of hydrogen; in more concentrated acid (especially also in hydrochloric acid) and at higher temperature the spontaneous dissolution sets in after a short time. As the activity ceases with the interruption (or even the weakening) of the current (Rathert), a hydrogen charge of 1 atmo. is not sufficient to keep up the activity. Without discussing how the Cr potential arises, the author suggests that this potential is only dependent upon the hydrogen charge. Chromium will spontaneously activate when placed in acid of a strength exceeding 0·01 N; in weaker acid the potential becomes more negative on kathodic polarisation; in order to maintain the activity, the hydrogen charge must be maintained. Diagrams explain how potential and activity are influenced by the diffusion of the hydrogen into the Cr, by current density and by anodic polarisation; in hydrochloric acid there is probably an activating influence of chlorine ions, which is not further discussed. Since the Cr potential also varies with the metal on which the Cr is deposited and is greater on copper than on silver and gold, it is suggested that the Cr deposited on Cu contains most hydrogen. There are difficulties as to the behaviour of Cr in solutions of KCl, in which the metal is not activated by kathodic polarisation; here the hydrogen apparently does not diffuse into the interior of the metal.

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